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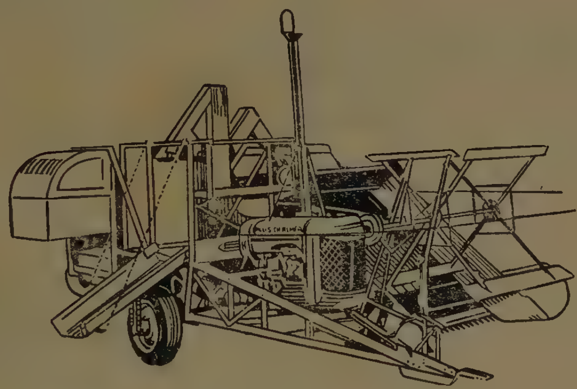

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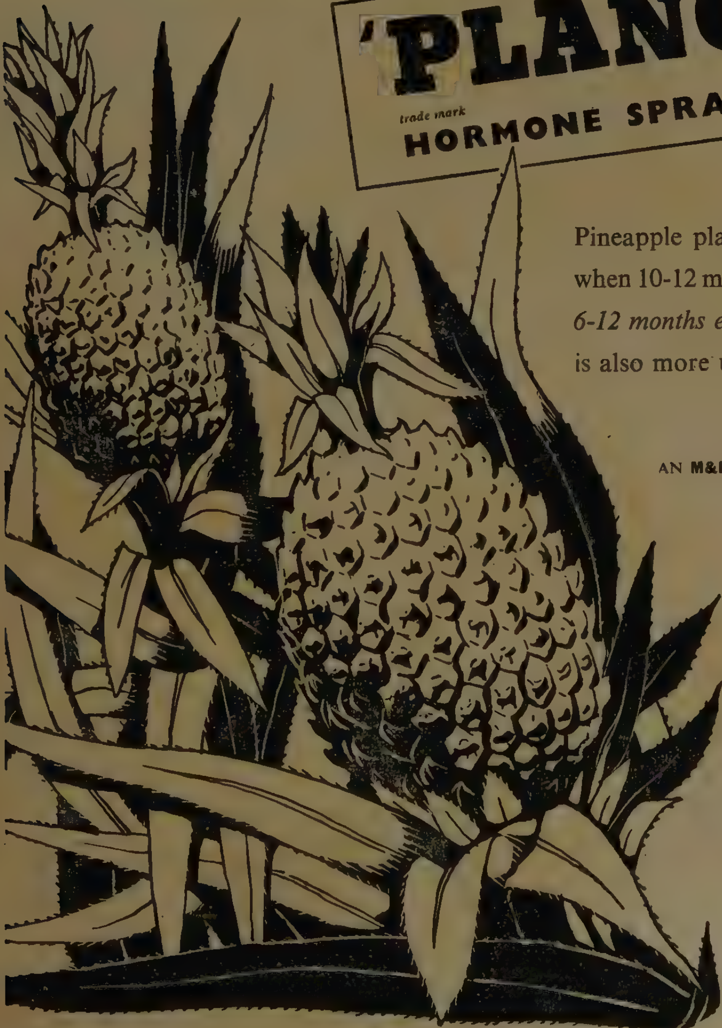

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SULPHUR AND FOOD PRODUCTION

Recently, concern has been manifested over the sulphur balance existing in East Arica. The Agricultural Department of Uganda has demonstrated that in many parts of the country the vegetation and crops are suffering from a sulphur deficiency and the Fisheries Research Organization have found that a shortage of sulphates in the water of Lake Victoria is limiting the growth of phytoplankton. As plankton is the principle food of *Tilapia* sp., the fish of greatest economic value, this apparent sulphur deficiency is of primary importance.

Sulphur is absolutely essential to life, not merely as chemicals, medicines, rubber and paint but as part of our bodies, animals and the vegetation. It is present in nearly every protein; for example as casein in milk, globulin in blood and keratin in horn and hair. The proteins are not all necessarily beneficial however, as for example, neither the diphtheria toxin nor the tobacco virus could exist without sulphur. The complete sulphur cycle in the world is shown diagrammatically below.

Relatively little of the earth's sulphur is available for our use. According to the geologists, at a depth of 750 miles below the earth's surface there is a layer 1,050 miles thick consisting of molten sulphides and oxides, but these being of heavy metals such as iron and nickel do not move into the upper horizons of the earth to any great extent. In some parts of the world elemental sulphur is mined in vast quantities but no such deposit is worked in East Africa. Here, our only source of commercial sulphur is gypsum or calcium sulphate. This is deposited on or near the land surface in arid regions and large expanses exist in the Northern Frontier Province of Kenya. Its principal use is as fertilizer, either directly or *via* the medium of superphosphate. Apart from the gypsum outcrops the only concentrations of sulphur in East Africa are near the volcanoes, as for example in the Njorowa Gorge at the base of Mt. Longonot, and in the salt lakes. The flood plain of Lake Manyara contains about 1 per cent sulphur as sulphate, that of Lake Rukwa contains 0.6 per cent and the soda crust of Lake Magadi has 0.1 per cent sulphur.

In other parts of the country we are entirely dependent upon the sulphur stored as proteins and aminoacids in the vegetation. As is shown in the diagram, soluble sulphates in the soil are taken up by plants where they become biologically converted to certain aminoacids such as cystine, and to proteins. The plant can only utilize the soil sulphur as sulphate, the roots do not absorb any other form. Work carried out by the author on East African soils, however, has shown that the presence or absence of soluble sulphates at any one time in a soil is immaterial. Very little useful information can be obtained from a simple sulphate determination. The decisive factor affecting the sulphur fertility of a soil is its power of converting the protein sulphur of organic matter into sulphate. The sulphate ion itself is extremely mobile and if not taken up by plant roots is rapidly leached away. Thus the ideal state is one in which the humus from organic litter is gradually and *continually* oxidized to sulphate. This ensures a sufficient and constant supply of sulphur in a form available to the plants.

The oxidation of organic sulphur to sulphate is mainly carried out by micro-organisms in the soil. Typical organisms are the bacterium *Achromobacter cystinovorum* which quantitatively converts cystine into elemental sulphur, the bacterium *Thiobacillus thiooxidans* which converts the elemental sulphur into sulphate and the fungus *Aspergillus niger* which can convert cystine directly into sulphate.

So far, soil investigations have been confined to forests which have been found to be well-endowed with the necessary sulphur-oxidizing micro-organisms. In a typical forest soil profile, whereas nearly all the sulphur in the topsoil is in the organic form, that in the subsoil is as sulphate. Thus, on oxidation the humus-rich topsoil provides sulphate which, although leached into the subsoil is available to the deep-rooted forest trees. After being biologically reconverted into the organic form the sulphur is returned to the soil as leaf litter.

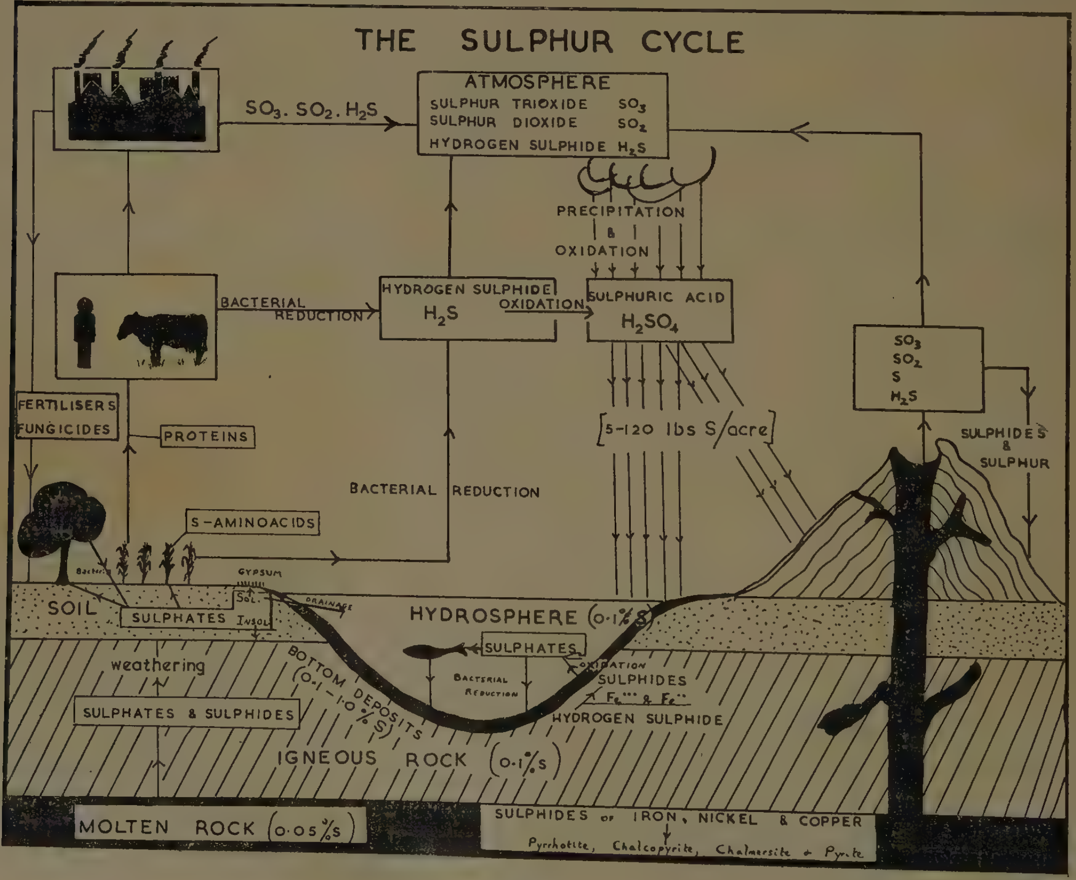
It is obvious, therefore, that the role of the sulphur-oxidizing bacteria and fungi in East African soils is extremely important. We must find the optimum conditions for their growth and at what periods they are most active. It has already been found by the author that drying out and then re-wetting the soils has a most beneficial effect upon the sulphur-oxidizing organisms. This suggests that the sulphur oxidation of organic matter is most likely to be greatest at the end of the dry season and the beginning of the rains. In this

case the produced sulphate would rapidly be leached away and unless a crop was deep-rooted it might not benefit from the oxidation.

Investigations made so far on the possible sulphur deficiency in Lake Victoria have confirmed that the water is indeed lacking in sulphate. The total sulphur content of the water is not more than one or two parts per million and this is mainly in the organic form. The mud on the other hand is extremely rich in sulphur. Unfortunately this large accumulation of sulphur is mostly in the form of undecomposed vegetable matter which is continually being overlaid with more of its kind and with silt. Thus, it is for the most part unavailable.

The protein sulphur of animal remains is more easily broken down than that of plants and thus in the interests of maintaining the fertility of the lake it is desirable to circulate the sulphur from plants through animals (such as hippos and fish) back to the lake bed. According to Beauchamp the sulphate shortage in the water is limiting the amount of plankton, which in turn will limit the growth of fish, which will limit the amount of easily oxidizable sulphur returned to the lake. To make matters worse, overfishing the lake is reducing not only the fish but the much-needed sulphur in the fish, and the means of maintaining the desired sulphur circulation. As most of the soluble sulphates produced in the soils surrounding Lake Victoria will be leached into the lake it has been suggested that these soils are probably deficient in sulphur. The only evidence of this to date has been the appearance of "tea-yellows" near Jinja but, unfortunately, plants can suffer from a symptomless sulphur deficiency and will not obviously lack the element. An insufficiency of sulphur in the vegetation may indirectly affect the animal industry. An investigation made into the craving for earth-licks by cattle in East Africa has yielded evidence that sulphur in the form of sulphate may be the main attraction. Work at present in progress on the sulphur balance of East African pastures should help to elucidate this problem.

P. R. HESSE.



FOOD STORAGE PROBLEMS IN UGANDA IN RELATION TO INSECT PESTS*

By A. P. G. Michelmore, Department of Agriculture, Uganda

(*Received for publication on 6th August, 1955*)

The Entomology of stored products is a subject in which there is still much to be found out, but in Uganda the need for research is overshadowed by the need for propaganda and practical action. The huge losses of food are appreciated by few, and by others are accepted as inevitable. In 1953, Uganda unexpectedly produced an enormous, record maize crop. Welcome as it was in some ways, it embarrassed Government, which had promised to buy it, but then found itself losing large quantities from insect damage. This loss may in the end prove a blessing in disguise by drawing attention to the need for more and better storage and transport.

In the poor continent of Africa, Uganda is exceptional. In the south and the other wetter areas, the rich soils and the two good rainy seasons permit two harvests and enable food of some kind to be gathered throughout the year. The country people therefore have little need to store food but subsist mainly on green bananas and sweet potatoes. On the other hand the cost of transporting this bulky fresh food makes it expensive for town dwellers and for feeding large numbers of labourers. In consequence, there is a growing demand for dry foods which can be stored, particularly maize. In the north and other drier parts of the country there is a more severe dry season, which compels the people to rely on crops which will store, particularly grain. With its rapidly growing population Uganda therefore needs to pay more attention to food storage.

Chief Foods Stored

In the Eastern Province particularly, tubers of sweet potato and cassava are sliced and dried, as the New Year dry season sets in, and are used to tide over the hungry period before the main grain crops ripen in the mid-year dry season. They are subject to a variety of beetle and caterpillar pests.

Various pulse crops are used throughout the country. Few of them can be stored for long, owing to the ravages of Bean Beetles (Bruchidæ), some of which start as field pests and come in to store with the crop at harvest time. Exceptions are black gram and the field peas grown in Kigezi, which often keep well for two years. Groundnuts are soon attacked by Red Rust Flour Beetle (*Tribolium castaneum*) and other pests, if shelled, but keep well in the shell. Being bulky to transport in the shell, they are best kept in the hands of primary producers as long as possible and only shelled and sold as needed for consumption.

Finger Millet is a staple food over large parts of Uganda and is, fortunately, resistant to insects. Stocks up to thirteen years old in ordinary wicker native granaries have been found in very fair condition. On the other hand, the Lesser Grain Borer (*Rhizopertha dominica*) has been found attacking stocks only five years old, so too great faith must not be placed on immunity.

Sorghum is used as a subsidiary food in the Finger Millet areas and is used widely for beer. When stored in the head, as it commonly is, it suffers greatly from Angoumois Grain Moth (*Sitotroga cerealella*), and when threshed it is soon eaten out by Rice Weevil (*Calandra oryzae*) and other beetles.

Rice, like sorghum, is a very susceptible grain. Though only produced in small quantities in the country, large amounts have to be imported, chiefly for the Asian community.

Maize is grown mainly in the southern half of Uganda as a cash crop and has increased greatly in importance of recent years. The most urgent problems at present are connected with this crop, because it is very liable to attack by Weevil and other pests, and because, being a commercial and not merely a domestic crop, such large bulks are stored together.

Principles of Good Storage

The basic principles of storing agricultural produce in such a way as to preserve it from insects and other agents of deterioration are

* Paper read at a Conference on the Medical, Agricultural, and Veterinary Aspects of Food Production in East Africa, March, 1954 (*see* this *Journal*, Vol. *20*, 1954, page 15).

unknown to many and by others are deliberately flouted for commercial gain. They are—

firstly: thorough drying,
secondly: rotation of stocks,
thirdly: good construction of stores,
fourthly: sanitation of stores,
fifthly: control of rats,
sixthly: correct building of stacks, and
lastly: the use of insecticides.

The drier a food product is, the better it keeps. Although different pests can stand different levels of dryness, they all feed and breed more on damp than on dry produce. By their activities they produce heat in a bulk of grain which will start physiological processes in the produce itself. In particular, moisture is caused to move and to concentrate in certain spots, which then heat up still more, with increased breeding of insects, respiration by the grain and development of micro-organisms. These hot spots grow and spread through a mass of grain, which may in the course of a few months be reduced to a rotting mass.

The domestic foodstuffs of the country folk are gathered in small quantities, which are usually adequately dried. The practice of storing grain in the head allows it to go on drying in the store. It is with the big commercial crops, particularly maize, that drying is often insufficient. There are several reasons for this. A crop stored in large quantities needs more thorough drying than small domestic stocks; the maize crop has to be got out of the way before the cotton season starts, so maize buying cannot be delayed until the whole crop is dry; the producer does not see the results of imperfect drying and so has no incentive to dry carefully; the system of officially fixed prices gives no incentive to anyone in the trade to select good produce and reject bad, but merely encourages a big turnover of anything that can be sold again; the system of paying simply by weight and not on a sliding scale by moisture content encourages people to sell their produce wet and therefore heavy; finally, Uganda has a damp climate. The crop ripens in the mid-year dry season, but the drying period is overtaken by the second rains. Maize with from 16 to 20 per cent moisture content often comes in to Kampala in transit. This could probably be avoided, but even with every care it is difficult to get the main crop in with less than from 14 to 16 per cent moisture. The maize would come in drier if it could be grown in the second rains and ripened in the hotter New Year dry season. There are difficulties in doing this, but it might be possible to overcome them.

Maize not destined for immediate consumption must obviously be dried artificially. Formerly, it was mostly sent to Nairobi and conditioned and stored there and then brought back as needed later in the year. In order to avoid the double transport the Uganda Government recently built a large conditioning and storage plant at Jinja, but the plant has been unable to cope with the 1953 crop and has proved to have several defects from the pest control point of view. It may be necessary to set up drying installations at other centres and perhaps also to have small mobile plants as well.

In a country where stored products are so liable to deteriorate it is important to use up stocks in the same order as that in which they are received. Godowns should therefore be built with an entrance at one end and an exit at the other. Old and new season stocks should not be mixed, or the old will infest the new. Installations which hold stocks of foodstuffs at all times of the year should have several separate stores, each of which can be emptied and disinfested at least once a year. As far as possible, different products should be stored separately.

Foodstuffs can be stored perfectly well for one season in stores of rustic materials, such as wicker and plaster, or wattle and daub, with a thatch roof. The trouble starts when the time comes to put the next season's crop into the store, for it is impossible to clean out or kill all the insects bred up on the first crops and now sheltering in cracks and crannies. Stores designed for anything more than small domestic storage should therefore be well built of permanent materials and designed with as few internal ledges as possible.

Insect damage increases in geometric progression in a stock of foodstuffs, owing to the breeding of the pests and the growth of hot spots already described. It is therefore essential to keep the initial infestation as low as possible. Insect pests are often carried over from an old to a new crop by sheltering in cracks and breeding in odd grains or foodstuff debris fallen down or carried up on to ledges or into holes by rats. When an old crop is used up, and before a new one is brought in, it is therefore important to clean a store completely. Not only should the floor be swept, but all window ledges and exposed wall plates,

ventilators and even roof girders should be cleaned up. In centres where power is available, vacuum cleaners are helpful.

In addition to the trouble just mentioned, rats eat much food themselves. They also spoil much more with their excreta. Their droppings can dampen patches of grain and so attract insects and start hot spots, which may spread through the bulk.

It is not always realized that concrete and cement are not waterproof but will transmit water into stacks of loose or bagged grain laid against them. Stacks should always be built on waterproof layers or raised up at least four inches on wooden or other dunnage. They should not touch either walls or pillars, which are liable to condense moisture and start wet spots in the produce.

Insecticides are the final and complete means of controlling stored product pests. However, they cannot work properly, unless the precautions previously mentioned have been carried out. Insects lurking in cracks, holes or bored grains will escape treatment and come out later to infest a new crop coming in. A good store, after being thoroughly cleaned out from top to bottom of all remains of a previous crop, should be treated with a space insecticide, such as a smoke, aerosol or fumigant gas to kill exposed insects. Then all surfaces should be given a residual spray to deal with any insects which may have escaped the former.

In Uganda an incoming foodstuff must be assumed to be infested. The only certain way of disinfesting it is by fumigation. This can only be done by completely closing up a store, or by covering up carefully built stacks with gas-proof sheets. Fumigation is a dangerous operation needing trained personnel and can only be done in suitable buildings.

Another possible way of killing insects in grain is by mixing it with a persistent insecticidal powder such as BHC. This is easy to do by hand with small, domestic supplies and is specially recommended for beans. For large quantities it is not easy to do unless the powder can be added automatically to a flowing stream of grain. In present conditions, when it means unbagging the produce, mixing by hand, and rebagging, it is seldom practicable on a large scale.

Another alternative is killing pests by heat treatment. It would be an advantage if drying and disinfestation could be done in one operation. So far, we have not found the right machinery for doing this in East Africa, but the subject needs following up.

Bagged stacks of foodstuffs not already heavily infested may be partly protected by sprinkling insecticidal dust on the floor and dunnage and on each layer of bags as they are built up, and redusting the top and sides of the stack at intervals. Once a bagged stack is thoroughly infested with insects, only fumigation will save it. This can only be done if the stack is properly built, with working space all around and above it. It may be futile if the premises are such that insects will reinfest the stack at once.

Some Problems and Remedies

In many countries maize is dried on the cob in cribs by primary producers before selling. Cribs should be protected from rain at the sides as well as above but should be well ventilated and narrow. The grain will dry more quickly if the sheaths are removed but will then be quickly attacked by insects, particularly Rice Weevil and Angoumois Grain Moth. Recent work in Kenya suggests that heavy doses of BHC dust mixed with the cobs will prevent this, but for Uganda the simpler method of leaving the sheaths on is advised. Unfortunately, many cobs have the tips torn open in the field by birds and other agents. Such cobs are more heavily infested by insects both in the field and in store afterwards. It is therefore advisable to separate out all cobs with broken sheaths and to use or sell the grain as soon as possible. The remaining good cobs will then keep with little loss for several months, provided that they are not too near a source of infestation.

Most foodstuffs in Uganda are stored in bags. Bag storage is convenient for handling and can use ordinary godowns. On the other hand, it is not particularly convenient for pest control, besides using much labour in handling and locking up large numbers of bags, which are often both dear and scarce. An alternative is loose bulk storage. In closed receptacles, such as silos, this is by far the best method for controlling insects, as fumigant gases or admixed insecticidal dusts can be easily applied, and infestation from outside can be prevented. The produce must be well dried first. The method of storing in pits, with self-fumigation by production of carbon dioxide, may become practicable in Uganda, though it will not be as easy as in countries

with a severe dry season. Storage of loose bulks exposed on warehouse floors would not be safe in a country so full of pests, and the climate is too damp for outdoor bulk storage to be safe. Loose bulk storage needs to be combined with automatic handling machinery and special railway trucks and other vehicles. It then saves labour enormously. East Africa would be well advised to consider a long-term policy of changing over from bag to loose bulk storage and handling of agricultural produce. The change would have to proceed in an orderly way, through the ports' conditioning plants and main centres, and then through the steamers and road transport to the smaller collecting centres.

Most of the edible produce of Uganda is stored in bad conditions. This is partly due to ignorance of the dangers of bad methods. It is also due to the greed of the merchants, who try to handle too much produce without building big enough or good enough stores. Three remedies are needed. Firstly, the marketing needs to be reorganized, so that products are graded and both producers and traders get a good profit from a good product and are penalized for infested, damp and dirty materials. Secondly, legislation is needed in order to keep up the standard of the produce itself and to insist on good buildings and correct storage methods. However, laws themselves will be useless unless supported by an inspection service. Thirdly, the trade must be educated. We have recently produced a pamphlet on storage methods as a start, but we shall be preaching to deaf ears unless inducements are offered in the form of profits and penalties.

All this will cost time and money, but not even the fat and fortunate land of Uganda can afford to lose foodstuffs as it does. The problem is liable to neglect, because it falls between so many different groups of people. Joint action is needed first between the departments of Agriculture, Commerce and Medicine and the township authorities. Representatives of the producers and the trade could then be invited to help.

Certain aspects of the problem must be considered on a wider East African basis. One of these is fumigation, or the use of poisonous gases to kill pests. The gases can kill people as well as insects and rats, and can therefore only be used by trained persons under careful supervision. At present, no one East African territory can keep a team busy fumigating all through the year. A mobile team to serve the whole of East Africa is worth considering.

Another use for fumigation is to protect the country from foreign pests. Small imports of seed and plant products are already carefully controlled, but large quantities for consumption are difficult to deal with in the same way. Many stored products pests are already cosmopolitan, but there are others which must be kept out as long as possible. Examples are the Khapra Beetle (*Trogoderma granaria*), which can breed even in excessively dry grain, and *Caryedon fuscus*, a serious Bruchid pest of groundnuts in the shell. Facilities for large-scale fumigation at the seaports would help to protect East Africa from such pests.

Such facilities would be equally useful for our exports. Periodically our coffee market is endangered by other countries being afraid of importing Coffee Berry Borer (*Stephanoderes hampei*), which could be killed for certain by fumigation. At present it is accepted in Britain as normal that tropical produce should be infested with pests. If the export crops and the holds of the ships at the ports could be fumigated, much loss would be prevented and higher prices could be claimed.

In conclusion, it is clear that the pests of stored foodstuffs raise problems, which a world marching steadily towards starvation must solve or die.

A CULTIVATION SYSTEM FOR GROUND-WATER (VLEI) SOILS

By J. B. D. Robinson*, T. R. Brook† and H. H. J. de Vink*, Department of Agriculture, Kenya

(*Received for publication on 14th July*, 1955)

Now that many planters producing coffee (*Coffea arabica*) in climatic areas subject to periods of drought appreciate the value of mulching in terms of both soil improvement and enhanced crop yield [1] [2] [3], the need for more land to increase mulch grass production has become a problem on many estates. In addition to the development of suitable land outside the coffee, it is a recommended field practice to remove old, debilitated and uneconomic coffee now growing on the poorer phases of the Kikuyu red loam soil type, and replace it with Napier grass (*Pennisetum purpureum*) which is still considered to be the most satisfactory mulching material. These areas occur on the steeper slopes, have been subject to severe losses of top soil by sheet erosion in the past, and must in many cases have been unsuitable for coffee even when this crop was first planted. While the need to grow this mulch grass as a "crop", i.e. with adequate cultivation, manuring, etc. to obtain high yields, is stressed, mulch production areas of this type are frequently inadequate and the effective utilization of the ground-water or Vlei soils which occur on many coffee estates for mulch production would be of great assistance.

In the East of the Rift Valley coffee areas particularly, Vlei soils occur in the topographical depressions between, or surrounded by, the coffee soils on the ridges, and are virtually unused for crop production of any kind. They are sometimes grazed spasmodically by those estates with cattle, are sometimes cut for hay, and of recent years have been cut by power mower at the end of the rains as a source of mulch grass. The yield of mulching material from the poor indigenous vegetation, however, is low and is likely to become lower as repeated mowing encourages creeping grasses. If these areas could be cultivated to produce Napier grass they would, indirectly, make a very real contribution to increased coffee production. In addition, if cultivation of other crops was proved to be possible it could lead to a much greater intensification of agricultural effort in the whole region because there is a large area of such land available.

The Soil Problem

In its simplest form the problem of the Vlei soils is a physical one requiring a method of cultivation which will improve the soil-air to soil-water relationships. It follows, as a result of their topographical situation, that they are considerably influenced by both ground water and surface water moving from the surrounding higher land during the rainy season, in addition to the natural rainfall falling directly upon them.

The Vlei soils are very heterogenous in character and, apart from murram areas, behave in the field like heavy clay soils. Frequently they exhibit the profile characteristics of a true "Gley" formation. Perched water tables are a frequent occurrence during each rains' period, and since these areas are virtually flat, flooding is common. Hence they are aptly described by the practical agriculturist as being either too wet or too dry for crop production in the natural physical state.

The clay in these soils is of a type which absorbs water with consequent expansion (i.e. expanding lattice type, montmorillonitic) which makes drainage within the profile a slow process. Thus, after a single long rains' period under flat cultivation, severe structure loss is evident and the rainfall of a subsequent season is quickly prevented from moving freely down the profile once the cracks in the soil have closed up. Waterlogging then occurs, soil-air volume is reduced and the crop either fails or struggles through to a very poor harvest depending on the severity of the adverse soil conditions.

A true reflection of the natural soil physical conditions may be obtained by observing the root distribution of indigenous Vlei herbage.

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† Assistant Soil Conservation Officer i/c Nairobi District H.Q.

Observations, recorded with random samples of Vlei herbage taken from the proposed experimental area at the Coffee Research Station, showed that in the top four to six inches of strongly mottled soil both the main and the fibrous root growth was vigorous. Below this top soil layer fibrous roots were hardly ever observed and the greater proportion of main grass roots were bent at right angles and were growing horizontally over the top of the underlying clay pan. The structure of this top four to six inches of soil was loose, friable and coarsely granular; that of the clay pan was massive cracking into columns at the height of the dry season.

The Cultivation System

Under soil conditions such as these the first consideration must obviously be that of an overall drainage scheme to facilitate the removal of excess surface water. It is necessary to align the general direction of cultivation within the main drainage framework and to construct diversion ditches or bunds to prevent surface run-off reaching the Vlei area from the higher ground.

With a planned drainage system to remove excess surface water and with a satisfactory diversion system prepared, the Vlei soil has then to be cultivated to produce maximum aeration and free internal drainage. For the reasons stated previously a normal system of flat ploughing and cultivation is of little or no practical value. It is essential to cultivate in such a manner that finally the soil is capable of shedding excess free water from the land surface after the soil has been wet to field capacity; of allowing free vertical drainage through the profile; and of permitting excess water to move away from the base of the free draining profile so avoiding soil saturation for prolonged periods. A system of raised convex shaped beds, termed Camber Beds, will ensure that these conditions are imposed upon the Vlei soil.

The Camber Beds are constructed with a slight fall ($\frac{1}{4}$–$\frac{1}{2}$ per cent) along the bed drains into secondary drains or into the main outlet drain. It is most important that the points at which the bed drains discharge into the main outlet drain are grassed down, i.e. with *Paspalum notatum* or *Cynodon* spp., and that the vertical fall from the bed drain into the outlet drain should not exceed six inches. Once erosion begins at the outlet it is very difficult indeed to control; masonry structures may be the only answer, for these soils can erode at an alarming rate.

The procedure in the initial stage may be summarized therefore as follows:—

(1) An accuurate survey should be carried out of the Vlei area, and every low spot noted.

(2) On completion of the map, the diversion or cut-off drain(s) should be planned. Similarly, the main outlet drain into which the Camber Bed drains will eventually discharge should be planned and sited. Usually the main outlet drain joins up the low spots.

(3) The layout and direction of the Camber Beds must be planned so that the correct gradient down the bed drains is obtained.

(4) Construction of the beds (*see* below).

(5) Construction of the main outlet drain(s) and diversion ditch(es).

The preparation and construction of this cultivation system is restricted to the driest time of the year. If, however, the land is very

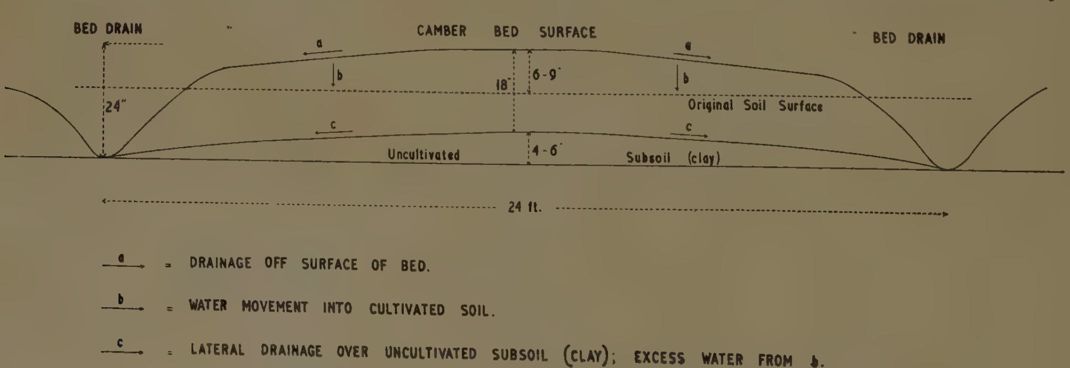

Fig. 1—Diagrammatic cross-section of a Camber Bed showing the three forms of drainage

waterlogged and unworkable by machinery, reverse items (4) and (5). In such wet conditions it may even be necessary to construct a temporary herring-bone drainage system into the main outlet drain to dry out the land.

The sequence of cultivation operations may be summarized as:—

(1) Mark out the boundaries of the beds, e.g. 24-ft. intervals if beds 24 ft. wide from the drain centres are to be constructed.

(2) Overlap ploughing from the centre of the proposed bed, working from inside to outside throwing the soil towards the centre. This operation should be performed to as great a depth as possible and will depend on the type of tractor and equipment available. A series of ploughings may be necessary if the equipment is very light.

(3) Subsoil over the initial camber formed by operation (2), to a depth of 18 in. or more, and with a lateral distance between cuts of not more than 22–24 in. This ensures, in fairly dry subsoil conditions, a good shatter effect, with the fracture lines of adjacent subsoil runs joining up.

(4) Take out the bed drains with a double mouldboard implement, preferably with extension arms fitted so that the spoil is thrown well up towards the centre of the bed. The depth of the bed drains should be at least 4 in. greater than the maximum depth of the subsoil operation. It is possible to carry out this operation with a light grader, and at the same time, to exaggerate the camber of the bed.

If shallow furrows are constructed for planting (along the length of the beds) they should be immediately refilled when the planting operation is completed so that the true convex shape of the bed surface is retained. Depressions on the bed surface serve to collect water, preventing efficient movement from the top of the bed into the drains. Soil structure within the cultivated layer will then be lost, from the bottom upwards, and the time between cultivation cycles thereby shortened.

Field Trial

A system of Camber Bed cultivation as described was completed at the Coffee Research Station, Ruiru, in March, 1954. In this instance parallel bed drains emptied directly into a main outlet drain running through the middle of the Vlei area. A graded diversion ditch with a 0.3 per cent fall for the first 100 feet and thereafter a 0.25 per cent gradient to the outfall, was constructed above the Camber Bed and was led into the main outlet drain at the edge of the Vlei area.

The method of bed construction used was:—

(1) The beds were marked out in 24-ft. intervals and were overlap ploughed twice with a Ferguson tractor and disc plough. With this light equipment a 6-in. initial camber was produced.

(2) The 24-ft. beds were then ripped with an International T.D.18 tractor and a Le Tourneau H3 ripper, two tines penetrating to 20 in., with cuts every 18 in. apart. This combination was excessively heavy for the job but was the only subsoiling equipment available. The Ferguson tractor was not heavy enough for a subsoiling job under the prevailing conditions.

(3) The Camber Beds were then built up, and the bed drains taken out with an International T.D.18 tractor and a Preco No. 2 terracer. Five rounds with the terracer were required to produce a cross section which showed an 18–20-in. difference between the crest of the bed and the base of the cultivation layer. Subsequently, this settled to 15–18 in. during the long rains of 1954.

Stage 1 in the construction of Camber Beds can be carried out by any tractor and disc or mouldboard plough implement, the number of rounds required to complete this stage satisfactorily depending on the equipment available. If a disc plough is used, disc scrapers are essential. Stage 2 requires rather more power than a Ferguson tractor possesses to give a reasonable depth of cut, and a track-type tractor is preferable to a wheel type. For example, a David Brown "Trackmaster" will pull a single-tine Killifer ripper to a depth of 18–20 in. in most Vlei soils after stage 1 ploughing. Similarly, if the double mouldboard attachment is used on the Killifer ripper, the David Brown "Trackmaster" will take out the bed drains for stage 3 satisfactorily. We have found that the small Fiat tractor, Model 25 Cs (Diesel), is slightly underpowered for completion of this job in one run, but two runs will give a satisfactory result. A total of 10 beds were constructed as outlined for the trial.

As no information was available on the cropping capacity of these soils, or the response to fertilizer and manure application, it was decided to grow a crop of maize (Yellow Durum) during the long rains, 1954, to serve as an indicator crop. The planting of Napier grass was deferred until a later stage pending the results from the maize trial.

Soil tests carried out on samples taken from the area before cultivation was completed did not give pH results of less than 5.5–6.5 for the topsoil samples; the pH values showed variable increases with soil depth. It was decided, therefore, not to include a liming treatment. Comparative laboratory incubation experiments, using a Kikuyu red loam soil from a typical Napier grass area as the control, showed only a very slow degree of nitrification in the Vlei soil. Comparatively high ammonia nitrogen and low nitrate nitrogen values were obtained from a standard test. (Three weeks at 30° C; soils wet to approximately 50 per cent available water content.)

Finally, it was decided to investigate the responses to nitrogen as ammonium sulphate, phosphorus as granular double superphosphate (placed at the time of planting) and cattle manure. Both maize and Napier grass respond to phosphorus on the adjacent Kikuyu red loam soils, and cattle manure would, it was felt, give some degree of micro-nutrient application, should any severe deficiency exist, in addition to any physical benefit it might confer. Further, it has been shown that mature coffee does not respond to applications of cattle manure (2, 3), whereas Napier grass grown on the poorer Kikuyu red loam soils does (4, 5). It is therefore sound agricultural practice to apply available cattle manure to the coffee mulch grass production areas.

Three of the Camber Beds constructed were put down to a pineapple trial by Mr. H. R. Evans, Assistant Agricultural Officer (Hort.), and will not be described here, except to note that growth has been good to date. The tenth Camber Bed was put aside for observing the growth and production of various miscellaneous crops, e.g. Lucerne, Edible Canna, Rhodes grass and Bananas for cattle feed.

Maize Trial (Yellow Durum)

Three balanced replications of a 2^3 factorial design were laid down on six Camber Beds at the beginning of the 1954 long rains' season. The plot size was 1/60 acre, and the plots extended from bed drain to bed drain with the width of the bed serving as two of the plot boundaries. Adequate guard row space was allowed between plots along the length of the beds. The three blocks were sited across the six beds to effect as much control as possible over soil variation from bed to bed.

The maize was planted on 30th April, 1954, in rows 4 ft. apart, with 3 ft. between plants in the row, and was harvested and weighed on 1st September, 1954. Three seeds were planted per hole. Between 1st April, 1954, and the harvesting of the crop, approximately 25 in. of rain was recorded, the majority of this falling in April and May. Mean treatment yields and yield effects are given in Table I:—

TABLE I.—COB MAIZE. LONG RAINS, 1954

(Figures in brackets are yields expressed as 200 lb. bags of maize per acre)

Treatment	Yield (cwt. per acre) (Means of 3 replicates)		Yield Effects of Treatments (cwt. per acre) (Mean of 12)	
(1) ..	7·03	(3.2)	—	
N ..	15·31	(6·9)	+4·27*	(+1·9)
P ..	17·65	(7·9)	+6·89**	(+3·1)
C ..	34·75	(15·6)	+22·73***	(+10·2)
NP ..	20·71	(9·3)	− 0·14	(−0·06)
NC ..	35·29	(15·8)	−1·40	(−0·6)
PC ..	38·18	(17·1)	−1·12	(−0·5)
NPC ..	43·39	(19·4)	+2·47	(+1·1)

NOTES;—

N=2 cwt. of ammonium sulphate per acre.
P=1 cwt. of double superphosphate per acre.
C=20 tons of cattle manure per acre.
SE. for yield effects=± 1·82 cwt. per acre Cob maize.
L.S.D. for yield effects at 5 per cent=3·89 cwt. per acre Cob maize.
L.S.D. for yield effects at 1 per cent=5·44 cwt. per acre Cob maize.
L.S.D. for yield effects at ·1 per cent=7·51 cwt. per acre Cob maize.

The phosphatic fertilizer was placed in the hole at the time that the maize was planted and the nitrogenous fertilizer was applied when the maize was between 6–8 in. tall, in a circle around each plant. The cattle manure was applied just before planting and was lightly worked into the topsoil.

Significant yield responses were obtained for the three single factor treatments only. The very substantial response to the cattle manure is difficult to understand. It seems unlikely that the major influence resulted from any nitrogen and phosphorus which it contained, in the light of the responses to the nitrogen, phosphorus and nitrogen plus phosphorus treatments. It was, therefore, more probably

the result of added micro- and/or macro-nutrients (the soil is chemically rich in potassium) or to some physical effect on the topsoil.

Observations made during the course of this experiment clearly indicated that more forward growth occurred in all plots treated with cattle manure. The control plots were very poor throughout and at the time of harvesting much of the maize cob was still immature.

In addition to recording the crop yields the sun-dried stover was also weighed to provide some relative information on the yield of vegetative material. Coffee estates which maintain cattle herds may be interested in producing maize silage on these areas. No simple direct relationship between the sun-dried stover weight and maize silage yield exists, because the stover was mature and dry and the plant spacing was wider than that used in the production of maize for silage.

TABLE II.—MAIZE STOVER (SUN DRIED) LONG RAINS 1954

Treatment	Yield (tons per acre) (Mean of 3 replicates)	Yield effects of Treatments (tons per acre) (Mean of 12)
(1) ..	0·93	—
N ..	2·24	+0·89**
P ..	1·28	+0·74**
C ..	4·12	+2·95***
NP ..	3·18	+0·21
NC ..	4·72	−0·46
PC ..	4·87	−0·15
NPC ..	5·69	+0·17

NOTES—
Fertilizer treatments as noted in Table I.
S.E. for yield effects = ±0·23 tons per acre.
L.S.D. for yield effects at 5 per cent = 0·50 tons per acre.
L.S.D. for yield effects at 1 per cent = 0·70 tons per acre.
L.S.D. for yield effects at ·1 per cent = 0·97 tons per acre.

Significant yield responses were recorded for the three single factor treatments only, as with the corn yield data. It is interesting to note that the yield response to nitrogen alone was greater than the response to phosphorus alone, whereas the greater response in terms of corn yield was recorded for the phosphorus treatment.

White Haricot Bean Trial

Since it was not considered desirable to plant Napier grass during the short rains because of the uncertainty of adequate rainfall, White Haricot Field Beans were planted on the trial area as a means of obtaining more crop yield data and information on responses to the soil treatments. Further, this crop is grown on coffee estates to provide food for the labour force. The nitrogen and phosphorus treatments were repeated as in the long rains maize trial but the cattle manure treatment was not.

The beans were planted on 1st November, 1954, at a spacing of 2 ft. by 2 ft. square, and were harvested on February 8th, 1955. Three seeds were planted per hole, and these were later thinned to a single established plant. The short rains amounted to a total of only 5.2 in. which fell between 28th October and 7th December. The first 1½ in. fell as very light showers with hot, dry periods between and was not very effective. The majority of the remainder fell during November. Mean treatment yields and yield effects are given in Table III:—

TABLE III.—WHITE HARICOT BEANS (THRESHED) SHORT RAINS, 1954

Treatment	Yield (bags per acre 200 lb.) (Mean of 3 replicates)	Yield effects of Treatments (bags per acre) (Mean of 12)
(1) ..	0·36	—
N ..	0·39	−0·05
P ..	1·90	+1·07***
C (residual)	1·28	+0·50***
NP ..	1·62	+0·03
NC ..	1·10	+0·07
PC ..	1·83	−0·32**
NCP ..	2·05	+0·18

NOTES—
N and P Fertilizer treatments as noted in Table I.
No Cattle Manure application.
S.E. for yield effects = ±0·09 bags per acre.
L.S.D. for yield effects at 5 per cent = 0·20 bags per acre.
L.S.D. for yield effects at 1 per cent = 0·28 bags per acre.
L.S.D. for yield effects at ·1 per cent = 0·39 bags per acre.

On the very inadequate rainfall it was surprising that any crop was reaped at all. In fact, yield increases were obtained to both the phosphatic fertilizer (placed, granular double superphosphate) and to the residual cattle manure treatment. This leguminous crop responded to phosphatic fertilizers very markedly, and as the phosphorus plus cattle manure (residual) effect was negative it seems likely that within the limits imposed by rainfall, the phosphorus content of the cattle manure might have been the active constituent. The nitrogenous fertilizer had no significant effect on yield.

Observations made during the course of the crop growth showed that the beans on all the plots which received phosphatic fertilizer, and to a lesser degree the plots which were originally treated with cattle manure, were more forward in growth. During the restricted period of adequate rainfall in November, the beans on these plots made more effective use of the available moisture and this was reflected in the final yields.

Vertical Moisture Distribution in the Vlei Soil Profile

During the long rains, 1954, soil samples were taken at selected vertical intervals on the Camber Beds and on the adjacent, uncultivated Vlei area. In each case, three random samples were taken at each depth interval and were bulked for a single soil moisture determination. Samples were taken from two of the Camber Beds and from two positions in the nearby uncultivated Vlei.

The relationship of adjacent moisture values above and below any given depth interval is considered to be an indirect measure of the physical condition of the soil. The soil moisture results together with the daily rainfall figures for the sampling periods, are given in histogram form (Fig. 2). The first recorded rainfall value for 30th March, 1954, marks the beginning of the long rains.

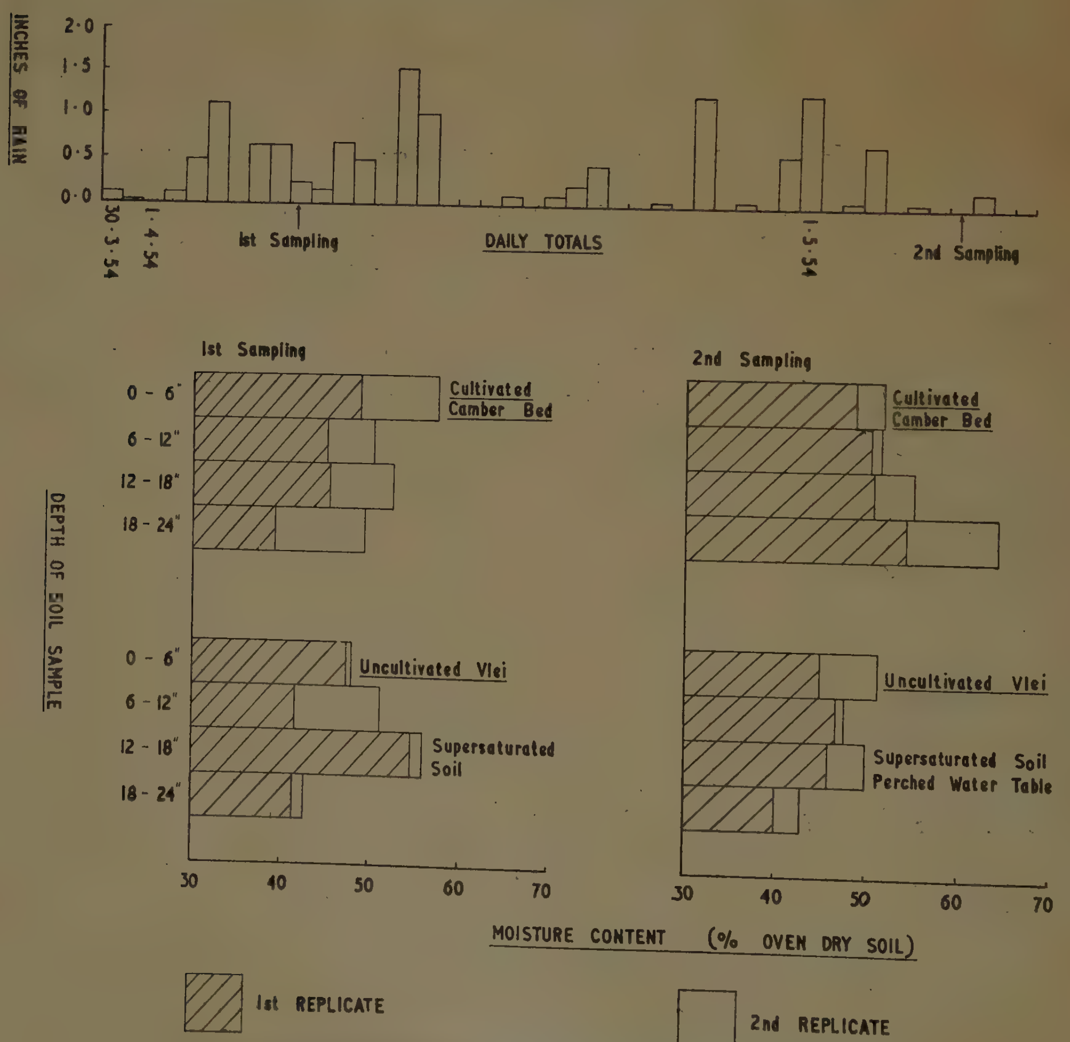

Fig. 2—Soil moisture distribution in cultivated and uncultivated Vlei soil profiles

The first sampling time was preceded by a little over three inches of rainfall. The Camber Bed soil profiles were progressively drier with successive vertical intervals and were not fully wet to field capacity. The uncultivated Vlei soil profiles, however, were progressively wetter with depth to the 12–18-in. layer which was saturated with water. The soil at 18–24 in. deep was quite dry and crumbly. The explanation of the apparent rapid downward movement of water in the uncultivated Vlei soil seems to be that water moved down the large cracks which had formed in the soil during the preceding dry weather. These had almost completely sealed up again on the surface at the time of sampling. The low value for the first replicate (6–12 in.) is the result of murram in the sample.

The contrast of vertical moisture distribution between the cultivated and uncultivated Vlei soil was apparent at the time that the first samples were taken. When the second set of samples were taken the differences were even more marked, and appeared to have followed a predictable trend. A total of about 9 in. of rain had been recorded by this time. Prior to sampling there had been two days with no recorded rainfall which permitted a large degree of natural distribution within the profile. In the Camber Bed profiles soil moisture increased with depth to the 18–24-in. level, which coincided with the base of the subsoil cultivation. This soil was very wet when sampled but was not supersaturated in that free water could not be squeezed out of it readily by hand. It appeared that water in excess of crop and field capacity requirements was draining to this depth quite freely and was then moving laterally over the uncultivated subsoil.

The uncultivated Vlei soil profiles showed a very different moisture distribution pattern. The perched water table at the 12–18-in. depth had persisted, with the consequent saturation of the soil above. Very little increase in soil moisture was recorded in the samples at 18–24 in. The Camber Bed cultivation had substantially influenced the internal drainage characteristics of this Vlei soil.

In the data recorded for the second sampling the moisture content was greater in the samples taken on the Camber Bed cultivated Vlei area. This may be explained by the fact that the cultivation had effectively increased the pore space in the soil.

Discussion

The Camber Bed system of cultivation has been introduced experimentally with the primary object of finding a method of increasing Napier grass mulch production in the drier coffee areas of Kenya. Considering that the Vlei areas of this region have never before been effectively harnessed for agricultural utilization, the results of 1954 trials with Yellow Durum maize and White Haricot Beans, as well as the excellent growth of the pineapples, indicate the high potential value of Vlei lands for future crop production. There is also good reason for confidence that the main Napier grass trial now planted (N.B. with three eye setts) will be equally successful. We have therefore recorded our earlier results here, despite the fact that we have not proved our point with regard to Napier grass mulch production, because we are of the opinion that a greater degree of experimentation with the Camber Bed system of cultivation is very desirable.

It will be noted that the Vlei trial described here was not a comparison of Camber Bed versus flat cultivation as would appear to be a more rational preliminary approach. The reason is that without a system of raised bed cultivation past experience has shown crop failure to be almost a certainty. The fact that in an occasional year when rainfall is poor, flat cultivation of Vlei areas may result in some crop production is no valid reason for taking up valuable experimental time investigating this problem. Further, it is certain that if flat cultivation of Vlei land was feasible, then it would already be an established part of practised land utilization.

We are now able to say that if a Vlei area having a minimum depth of 2 to 3 ft. of soil, is cultivated on the Camber Bed system as described here, the production of economic yields of some crops is a feasible proposition. With the particular Vlei upon which this experiment is being conducted, crop responses have been obtained to nitrogen and phosphorus fertilizers, and to cattle manure. Application of the latter was at a fairly high rate, and it is not unreasonable to postulate substantial crop yield increases for a dressing of 10 tons per acre and even, possibly, 5 tons per acre of this material. In the coffee areas there is good reason to anticipate that the application of cattle manure to Napier grass crops for mulch production on Vlei areas will prove to be economically sound.

Plate I

Plate II

Views of the Napier grass plots on the Camber Beds. Note will be taken of (a) the bund below the diversion ditch in the foreground of Plate I, (b) the even germination but substantial growth differences between the plots, (c) the bed drains running down into the main outlet drain (not seen), and (d) uncultivated Vlei in the middle background with, behind it, coffee on the higher ground (red soil)

Summary

1. A detailed account is given of the Camber Bed system of cultivation which has been the subject of experimentation on a typical Vlei soil area at the Coffee Research Station, Ruiru, Kenya.

2. Yield results for Yellow Durum Maize and White Haricot Beans are reported for these crops produced on a Vlei soil cultivated in this manner. It is also recorded that pineapples are growing well on the same area.

3. It is emphasized that although these results are only of a preliminary nature to date, their potential value can be considerable.

4. The main purpose of this work has been directed towards a means of further increasing the perennial production of Napier grass for mulch in the drier Kenya coffee areas. This important aspect of crop production on these areas is now under long-term investigation.

Acknowledgments

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E.A. MILK RECORDS OF LEADING COWS (December, 1954, to June, 1955)

By the East Africa Milk Recording Scheme, P.O. Box 478, Nakuru, Kenya

CLASS I (UNDER 2 YEARS OLD)

Name and Address of Owner	Name of Cow and Sire	Breed		Date of Birth	Lactation Records: No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
1	2	3		4	5	6	7	8	9	10
Hafod Estates, Limuru	Hafod Liquid, *Preston Supreme.*	Ayrshire	P	9–6–52	1st	13–5–54	5,863·5	305	3·98	233·37
Gingalili Ltd., Nakuru	Gingalili Janine, *Rutje's Eduard.*	Friesland	P	13–2–52	1st	13–12–53	6,049·2	305	4·60	278·26
F. R. Stephen, Nairobi	Sukari No. 13, *Ondiri Monte Carlo.*	Guernsey	N.P.	24–4–52	1st	5–3–54	4,921·0	212	4·27	210·13
P. N. Dearlove and A Jowitt, Ainabkoi	Southernwood Edina's Faith, *Lynmouth Noreen's M.P.II.*	Jersey	P	4–7–52	1st	1–7–54	3,066·5	211	6·96	213·43
Lt.-Col. R. D. Gordon, Nakuru	Star, *Pearceland's Fancy.*	Jersey	N.P.	28–4–52	1st	3–4–54	6,446·9	305	5·37	346·20

CLASS II (UNDER 2½ YEARS OLD)

Name and Address of Owner	Name of Cow and Sire	Breed		Date of Birth	No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
A. T. Hales, Eldoret	Mtarakwa Nymph 2nd, *Knockallan Royal Lad.*	Ayrshire	P	17–9–51	1st	4–3–54	8,240·5	277	3·95	325·50
Hafod Estates, Limuru	Hilda 3rd, *Kivulini Kates Baron.*	Ayrshire	N.P.	3–5–52	1st	1–6–54	6,490·0	296	4·55	295·30
Gingalili, Ltd., Nakuru	Gingalili Royalty, *Rutje's Eduard 3rd.*	Friesland	P	2–2–52	1st	15–5–54	5,739·9	220	4·15	238·21
Endrick Ltd., Elburgon	Cherry, *Barwyke Pathfinder.*	Friesland	N.P.	19–8–51	1st	29–1–54	6,864·1	305	3·40	233·38
Broomhill Estate, Kiambu (*b*)	Purity Flora's Pride, A.R. (Imp.) *Purity Rose's King.*	Guernsey	P	8–10–51	1st	22–3–54	6,811·3	305	4·72	321·49
P. E. L. Howard, Nakuru	Wascong 1st, H.21, *Cardington Robert 5th, P.B.*	Guernsey	N.P.	16–9–51	1st	13–3–54	5,710·0	277	5·26	300·35
R. A. Clay, Elburgon	Idehill Hurricane, C.M. (Imp.), *Samares Blonde Prince.*	Jersey	P	12–11–51	1st	3–4–54	6,551·5	294	5·55	363·61
Major and Mrs. L. B. L. Hughes, South Kinangop	Fiona, M.40, S.M. *Osirua Despot* (Imported) Vol. XII	Jersey	N.P.	15–12–51	1st	15–2–54	8,104·0	305	5·35	433·56
S. V. Aitchison, Ol Kalou	Red Rush, *Kisima Acacia.*	Red Poll	N.P.	5–6–51	1st	2–10–53	5,327·0	298	4·51	240·25
P. F. Roller, Nakuru	Monica, *Unknown.*	Shorthorn	N.P.	27–3–52	1st	24–4–54	5,784·7	277	4·09	236·59

P.—Pedigree. N.P.—Non-Pedigree.
(*b*) Foot and Mouth Disease.

CLASS III (UNDER 3 YEARS OLD)

Name and Address of Owner	Name of Cow and Sire	Breed		Date of Birth	Lactation Records: No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
1	2	3		4	5	6	7	8	9	10
A. T. Hales, Eldoret (*b*) ..	Mtarakwa Witch 3rd, *Knockallan Royal Lad.*	Ayrshire	P	19–8–51	1st	5–3–54	7,989·5	305	4·00	319·58
D. W. Crichton-Mackie, North Kinangop	Tanna, *Unknown.*	Ayrshire	N.P.	29–6–51	1st	19–5–54	8,050·2	305	3·61	290·61
Endrick Ltd., Elburgon ..	Endrick Cleopatra, *Barwyke Pathfinder.*	Friesland	P	7–5–51	1st	27–4–54	5,741·4	286	3·81	218·75
L. F. A. Green, Limuru (*b*) ..	Brenda No. 31, *Oldambster Don.*	Friesland	N.P.	28–2–51	1st	20–2–54	7,848·5	305	4·00	313·94
Broomhill Estate, Kiambu (*b*)	Defiance's Maple of Broomhill, *Cherkley Defiance.*	Guernsey	P	7–9–51	1st	29–3–54	6,462·2	305	4·94	319·24
Coull Farm, Nakuru	Kangarua III, 174, *Unknown.*	Guernsey	N.P.	2–4–51	1st	28–1–54	5,908·8	292	5·10	301·35
Mrs. W. S. Luke, Limuru ..	Brackenridge Moon Flower, *Chesham Worthy Security.*	Jersey	P	16–7–51	1st	1–3–54	6,657·4	305	5·77	384·13
R. A. Clay, Elburgon ..	Croix's Mercia, *La Croix Maharajah.*	Jersey	N.P.	31–7–51	2nd	25–6–54	5,574·2	269	5·23	291·53
John Bevan, Njoro (*c*) ..	Kisumu 86, *Groton Priscus.*	Red Poll	N.P.	21–8–51	1st	28–4–54	5,248·2	247	4·41	231·45
P. F. Roller, Nakuru	Samaki II, *Unknown.*	Shorthorn	N.P.	21–7–51	1st	22–1–54	4,549·9	298	4·47	203·38

CLASS IV (UNDER 4 YEARS OLD)

Name and Address of Owner	Name of Cow and Sire	Breed		Date of Birth	No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
Kabazi Estates Ltd., Nakuru	Skerrington Sport 4th, *Brocks Perfection.*	Ayrshire	P	15–12–49	1st 2nd	7–11–52 1–12–53	8,456·0 8,544·6	305 305	4·33 4·47	366·14 381·94
J. L. Downey, Limuru ..	Square 6th, *Mtarakwa Masterpiece.*	Ayrshire	N.P.	5–2–51	1st	9–7–54	8,987·8	295	4·52	406·25
Gingalili Ltd., Nakuru ..	Gingalili Julep, *Rutje's Eduard III.*	Friesland	P	5–10–50	1st	1–1–54	13,011·5	305	3·80	494·44
H. B. Fraser, South Kinangop	Beryl 40, *Karirana Sexton.*	Friesland	N.P.	8–3–50	1st 2nd	30–12–52 11–2–54	6,267·7 8,902·7	305 305	3·54 3·30	221·88 293·79
Coull Farm, Nakuru (*a*) ..	Coull Sunshine 1st, *Caradoc Tarragon.*	Guernsey	P	28–8–50	1st 2nd	17–3–53 30–3–54	4,807·0 4,669·2	287 294	5·39 5·48	259·10 255·87
S. S. Bastard & Son, Sotik ..	Ndoli I, *Unknown.*	Guernsey	N.P.	Mar., 1951	2nd	13–3–54	8,524·0	280	4·11	350·34
P. N. Dearlove and A. Jowitt, Ainabkoi	Southernwood Water Sprite, *Lynmouth Noreen's M.P.* 2nd	Jersey	P	15–2–50	1st 2nd	11–6–52 25–1–54	3,382·0 5,681·7	204 305	7·05 7·11	238·43 403·97
R. A. Clay, Elburgon ..	Croix's Sheilah, 96 C.M., *La Croix Maharajah.*	Jersey	N.P.	30–11–50	1st 2nd	8–3–53 6–4–54	5,502·0 7,264·7	305 301	5·32 5·76	292·71 418·45
John Bevan, Njoro (*c*) (*h*) ..	Enderby Mar's Juliet, *Kisima Mars.*	Red Poll	P	16–11–50	1st	7–7–54	7,528·5	297	3·39	255·22
John Bevan, Njoro (*c*) ..	Soiti No. 67, *Unknown.*	Red Poll	N.P.	27–6–50	1st	25–5–54	8,681·7	305	3·79	329·04
H. H. Peet, Nakuru	Solai Rosebud 2nd, *Mickle Golden Grain.*	Shorthorn	P	3–1–50	1st 2nd	4–11–52 18–12–53	6,466·8 7,070·3	305 305	3·93 4·39	254·15 310·39
H. R. Munro, Nakuru ..	Nyamurua II, *Kwetu Silas.*	Shorthorn	N.P.	30–8–50	1st	6–5–54	5,593·5	305	4·97	278·00

P.—Pedigree. N.P.—Non-Pedigree.

(*a*) Three-quarters only. (*b*) Foot and Mouth Disease. (*c*) Weekly Weighings. (*h*) Still Milking.

CLASS V (UNDER 5 YEARS OLD)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	Lactation Records: No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
1	2	3	4	5	6	7	8	9	10
Kabazi Estates Ltd., Nakuru ..	Kabazi Elf, *Kemsing Namesake.*	Ayrshire P	15–9–49	1st	27–2–52	7,020·3	305	3·68	258·35
				2nd	7–12–53	10,416·2	305	3·64	379·15
Kivulini Ltd., Molo	Maggie 7 *Mtarakwa Neptune.*	Ayrshire N.P.	15–7–49	1st	14–5–52	7,081·3	287	4·30	304·50
				2nd	18–4–53	7,612·1	279	3·90	296·87
				3rd	17–3–54	10,627·8	305	4·39	466·56
Gingalili Ltd., Nakuru ..	Karirana Geranium, *Oldambster Gysbrecht.*	Friesland P	3–8–49	1st	7–12–53	11,343·1	305	3·99	452·59
Gingalili Ltd., Nakuru ..	Gladys, *Glenavon Victor.*	Friesland N.P.	9–6–49	1st	20–3–52	8,595·8	305	3·78	324·92
				3rd	12–1–54	9,808·7	238	4·07	399·21
Blundell Estates Ltd., Nakuru	Beaurepaire Lady Richmond 28th AR. *Le Hamel Meteor.*	Guernsey P	18–7–49	1st	3–12–51	6,277·3	269	5·01	314·49
				2nd	18–11–52	5,269·7	305	4·68	246·62
				3rd	4–4–54	6,892·8	305	5·23	360·49
Blundell Estates Ltd., Nakuru	Menengai 4th C.9 *Fernhill Roberts Lad* 10th.	Guernsey N.P.	21–5–49	1st	28–1–53	8,000·6	305	4·57	365·63
				2nd	27–1–54	9,612·2	305	4·37	420·05
Manera Farm, Naivasha ..	Soysambu Margherita, *Hursley Pet's Dreamer.*	Jersey P	31–5–49	1st	16–10–53	8,091·5	305	5·49	444·22
D. E. Fielden, Nakuru ..	Nanyuki II 238, *Osirua Jupiter.*	Jersey N.P.	14–4–49	1st	17–9–51	4,545·4	245	5·72	260·00
				3rd	29–12–53	7,596·6	305	5·87	445·92
John Bevan, Njoro (*c*) ..	Kisima Jenny, *Kisima Mars.*	Red Poll P	12–12–49	1st	25–1–54	5,173·0	272	3·95	204·33
H. C. Coltart, Njoro (*b*) ..	Pemba No. 283, *Kambala.*	Red Poll N.P.	Under 5 years	2nd	31–5–54	9,602·0	305	4·01	385·04
Keringet Estate, Molo ..	Hathenshaw Wild Eyes 8th (Imp.), *Hathenshaw Lord Foggathorpe 5th*	Shorthorn P	5–10–49	1st	21–5–52	5,891·7	305	3·41	200·91
				2nd	29–5–53	6,437·2	305	3·57	229·81
				3rd	15–5–54	6,440·4	305	3·46	222·84
H. H. Peet, Nakuru	Binky 8, *Unknown.*	Shorthorn N.P.	1949	1st	8–8–53	6,456·0	305	4·30	277·61

P.—Pedigree. N.P.—Non-Pedigree.

(*b*) Foot and Mouth Disease. (*c*) Weekly Weighings.

CLASS VI (MATURE)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	Lactation Records: No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
1	2	3	4	5	6	7	8	9	10
Hafod Estates, Limuru	Llannerch Liquid 2nd (Imp.), *Barwheys Bell Boy.*	Ayrshire P	9–11–48	2nd	9–6–52	11,231·6	305	3·14	352·67
				3rd	26–5–53	10,872·5	303	3·61	392·50
				4th	9–5–54	12,768·5	305	3·64	464·77
J. L. Downey, Limuru (*b*)	Square 2nd, *Mtarakwa Masterpiece.*	Ayrshire N.P.	13–9–46	4th	3–3–52	*837·9 gall.	not officially recorded		
				5th	23–6–53	19,767·8	305	4·22	834·20
				6th	7–9–54	13,157·6	278	4·11	540·78
Barclay Estates Ltd., Menengai (*b*)	Bradwall Emperor's Lorna A.R. (Imp.), *Bradwall Lodge Emperor.*	Friesland P	8–10–48	1st	17–4–51	10,629·0	364	3·84	408·15
				2nd	6–8–52	14,963·4	305	3·51	525·22
				3rd	21–2–54	20,386·0	305	3·32	676·82
Manera Farm, Naivasha	P.7, *Unknown.*	Friesland N.P.	Unknown	1st	13–2–54	11,356·5	305	3·76	427·00
Rhodora Estates Ltd., Nakuru	Rex's Rose 6th of Pay Hay A.R. (Imp.) *Fernhill Robert's Lad* 6th.	Guernsey P	9–9–48	2nd	14–1–52	9,595·1	302	4·32	414·50
				3rd	26–1–53	10,199·1	305	4·75	484·46
				4th	16–2–54	10,292·7	302	5·05	519·78
Olbonata Ltd., Nakuru	Borana 551 G.48, *Ruth's Hero of Whitson.*	Guernsey P	27–1–48	1st	19–10–51	8,473·8	305	4·80	406·74
				2nd	28–1–53	9,164·7	305	4·45	407·83
				3rd	11–2–54	10,218·5	305	4·76	486·40
Mrs. W. S. Luke, Limuru	Osirua Successful Clover, *Osirua Wonderful Successor.*	Jersey P	3–12–44	2nd	3–12–51	6,102·2	310	5·20	317·20
				3rd	14–12–52	11,220·1	305	4·80	538·56
				4th	14–4–54	12,227·5	305	4·69	573·47
D. E. Fielden, Nakuru	Kongoni II C.M., O.M. *Osirua Jupiter.*	Jersey N.P.	4–11–45	4th	19–2–52	9,512·8	300	5·58	530·82
				5th	13–2–53	10,862·4	305	5·29	574·62
				6th	16–2–54	8,863·3	277	5·29	468·87
Kapsiliat Estate, Moiben	Kirton Mish Mash (Imp.) *Kirton Lucifer.*	Red Poll P	26–1–49	1st	24–2–54	6,084·0	280	4·54	276·21
H. C. Coltart, Njoro (*b*)	Chanda 185, *Unknown.*	Red Poll N.P.	Unknown	1st	18–1–54	8,446·0	303	4·17	352·20
H. H. Peet, Nakuru	Solai Rosebud, *Primeston Patrician* 3rd.	Shorthorn P	23–5–46	2nd	23–1–52	7,852·8	286	3·94	309·40
				3rd	14–4–53	6,463·9	239	4·70	303·80
				4th	11–2–54	6,651·6	287	4·19	278·70
P. F. Roller, Nakuru	Biuki, *Unknown.*	Shorthorn N.P.	Unknown	1st	3–5–52	6,390·6	305	4·92	314·42
				2nd	7–4–54	8,008·9	303	4·72	378·02

P.—Pedigree. N.P.—Non-Pedigree.

*Cow was ill for several months. (*b*) Foot and Mouth Disease.

SOME PREMISES AIMED AT INCREASED EFFICIENCY IN ESTATE MANAGEMENT

By E. J. D. Boothby, P.O. Box 13, Nakuru, Kenya

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The last hundred years has brought about a vast change in the standard of the various professions. In medicine, law, and engineering the average capability of the rank and file has increased a hundredfold, while farming is developing into a specialized study of an infinitely higher importance, and like Kipling's "Husbandman" we must have a great variety and a large number of widely diversified subjects at our finger tips. Indeed, we need to have at least some of the knowledge of the ploughman, the stockman, the veterinarian, the engineer, the lawyer, and the economist. This article is intended to give a brief view of the basis of efficient estate management from the economic point of view.

The Objects of Estate Management

In any business the object is to obtain the maximum amount of satisfaction, that is to obtain the maximum net return (the biggest surplus in the profit and loss account) while still maintaining the *status quo* of the unit in respect of fertility, pasture production, repairs and maintenance to buildings, fencing and machinery.

The Economic Unit

This is that size of estate or farm which under *Average Efficient* management and average costs and prices will earn interest at the current rate on the community value of that class of property.

It naturally follows that a property which is fully economic in times of good prices will not necessarily be economic in a period of depressed prices. Under super-efficient management a normally uneconomic property could be farmed economically.

Capital and Efficient Capitalization

Capital may be defined as wealth utilized to assist labour to produce more wealth from the land, and at any given time the capital involved in a farm or estate, or the capital value of a farming unit, means the sum the owner's equity or interest in that unit, if unencumbered by mortgages or other charges, would be expected to realize on the open market under reasonable terms and conditions. We must, however, realize that capital is not static but flexible, and that the capital value of one's farming concern can fluctuate rather violently in periods of depression or inflation. To utilize capital inefficiently in farming or any other enterprise is a seriously retrograde step for two reasons. Firstly because the bulk of farm overheads arise from the total amount of capital invested, and secondly because the capital is not available for use in a more profitable productive alternative.

Theoretically, a farm is efficiently capitalized when after paying all running costs, wages (including wages of management to the owner), repairs and maintenance, insurance, depreciation and other normal expenses, it is capable of returning to the owner interest on his capital invested at a rate not less than the current rate of interest he could obtain if the capital were invested in any other business enterprise.

Farm Overheads

The cost of running any productive undertaking or business may be divided into two distinct classes, namely fixed or overhead costs, and prime or variable costs. The relationship of these costs to one another have a very important bearing on the economic efficiency of the farming unit. Fixed or overhead costs of any business remain approximately the same regardless of the level of output. Production can be increased to a maximum or reduced to much less than capacity without any appreciable fluctuation of these costs. They include interest on the money invested in the land, plant, depreciation, insurance, and the basic rent.

Prime or variable costs include hired labour, grass seed, manures, the cost of fuel for cultivation and all costs which vary with the extent of production. It is noticeable that the estate or farm with the higher proportion of overheads can increase production more economically than the farm with the low overhead and high variable costs. In the latter case these costs increase proportionately with output, or even more than proportionately in many cases, so that net returns are not so favourable.

All business—and farming is a business—is aimed to produce goods at the lowest cost per unit, but in a business where variable costs are high the familiar law of diminishing returns is a contingent danger. That is, once a certain output is obtained, further production costs progressively more per unit to produce, but where there is a high ratio of overhead costs the farmer can confidently increase his output, for he is spreading these fixed costs over more and more units of production. Where overheads in farming are high it is a fundamental reason for farmers to increase output if they wish to obtain the maximum net profit.

Variations between farms cannot go unmentioned. The more dependent a farm is on purchased feedstuffs, fuel, seeds, manures and hired labour, the more important will be variable costs. On the other hand where little cultivation is done, where labour requirements are small and home-grown feed is produced, overhead costs become more significant.

Depreciation

Depreciation is the loss in value of an asset caused by the lapse of time despite repairs and maintenance being carried out. The amount that should be written off annually is largely a matter of opinion, but the prudent farmer endeavours to estimate the life of his buildings and plant, write a proportion off annually and pay it into a special depreciation fund to be drawn for the replacement of plant and buildings as they need to be renewed.

Interest

To obtain a true picture of the annual net estate earnings, interest on the farmer's equity in his unit should be charged against the farm. This represents the farmer's capital which he could have invested in Government stock, a fruit shop, or a country store. Having elected to invest his money in farming he should get at least 3 to 4 per cent on his capital.

Budgeting as an Aid to Estate Management

Budgeting is the working out of the past into the future and assuming that the past will be the future. Estate budgets are usually drawn up a year in advance and their value repays handsomely the work involved and should not be underestimated. Careful regard must be given to the use of sound costs and prices, and, because of the uncertainty of future prices, budget prices must be conservative except where prices are fixed.

A series of budgets for any given year will make estate owners and managers more cost-conscious and enable them to seek out more profitable farming alternatives. The subject of estate budgeting is very interesting and is in itself a profitable study, and it is hoped to give full particulars of the practice of budgeting in a later article.

It is the opinion of some of the world's greatest practical agriculturists that 75 per cent of farming is business acumen. The day of following in one's father's and grandfather's footsteps is gone forever. Farm and estate managers must therefore be zealous to give time and thought to the economic foundation of their farming practices, to the possibility of more productive alternatives in farming, and to the most profitable application of their farming capital.

REVIEW

THE FORESTER'S COMPANION, by N. D. G. James. Published by Basil Blackwell, Oxford, 1955. Price 12*s*. 6*d*.

This is a concise and ready source of information on many aspects of forestry in the British Isles, and is intended for all who work in the woods—landowners, land agents, foresters, timber merchants, woodmen, students, etc. It is handy in size in that it will go into a pocket, and is very reasonably priced although well printed and admirably assembled and produced. Its 31 chapters touch on most of the subjects in which a woodsman is, or should be interested.

While the basic principles of forestry are the same the world over, yet the specialized details of this book should be used with the greatest of care in East Africa for, of course, the difference in climate, elevation, etc., fundamentally alters the way the basic facts should be applied.

Some of the subjects are of great interest to East African farmers, such as hedges and shelterbelts, arboriculture and amenity planting, elementary surveying and timber measuring.

All in all it is a very useful little book, and rather the English counterpart of Eggeling's "Elementary Forestry" which was written essentially for East Africa.

THE ZEBU CATTLE OF EAST AFRICA

By H. Epstein, Faculty of Agriculture, Hebrew University, Jerusalem

(*Received for publication on* 12*th July*, 1955)

The Classification of the Humped Cattle of East Africa

Humped cattle may be grouped into two main divisions in accordance with the situation of the hump: In the one group the hump is cervico-thoracic, in the other thoracic (Curson and Bisschop, 1935). The first group is referred to as neck-humped, the second as chest-humped—terms of convenience subsequently employed in order to avoid the rather clumsy terms "cervico-thoracic-humped" and "thoracic-humped".

Neck-humped cattle include two groups, the neck-humped Zebu and the neck-humped Sanga. The neck-humped Zebu is recorded in ancient Egypt and Elam, but only one neck-humped Zebu breed has survived in Africa, i.e. the Afrikander cattle of South Africa, which are descended from the cattle of the Hottentots (Epstein, 1933). The neck-humped Sanga cattle, found in Ethiopia and the savanna belts of Africa, originate from the interbreeding of neck-humped Zebu and humpless longhorn cattle.

Chest-humped cattle comprise also two groups, the chest-humped Zebu and the chest-humped Sanga. The chest-humped Zebu ranges practically throughout the whole of southern Asia. It has been introduced into East Africa during recent centuries, and rapidly extended its range southwards and westwards. Chest-humped Sanga cattle are found in those parts of Africa where chest-humped Zebus have interbred with neck-humped Sangas or humpless longhorn cattle.

In East Africa all four basic types of humped cattle are encountered: the neck-humped Zebu or Afrikander, recently imported from South Africa; the neck-humped Sanga, the earliest type of East African cattle—at any rate, the earliest of those still in existence in this region*; the chest-humped Zebu, introduced from southern Asia by Arab and Indian traders, mainly since the Arab invasion of A.D. 669; and the chest-humped Sanga cattle, evolved in East Africa from the cross-breeding of chest-humped Zebu and neck-humped Sanga.

The term "chest-humped Zebu" is preferable to the term "short-horned Zebu" now in common use. Several chest-humped Zebu breeds in East Africa, distinguished either by fairly long and thick horns, as many Boran and Nandi cattle, or by the absence of horns, as the Zebus of Mbulu, Tanganyika Territory, and numerous Eritrean, Somali and Ethiopian cattle, cannot be called short-horned. Their inclusion in the term "short-horned Zebu" is obviously a misnomer. In India chest-humped Zebu breeds are encountered with very large and thick, occasionally gigantic, horns. Yet these breeds are closely allied to the shorter-horned, loose-horned or polled African and Asian Zebu cattle. The term "chest-humped" applied to all of them.

The cervico-thoracic hump is muscular, being formed by the extraordinarily well-developed cercival part of *Musculus rhomboideus*. The thoracic hump is musculo-fatty, owing to the musculo-adipose development of the thoracic part of *M. rhomboideus;* it does not consist purely of fat as the humps of the camel and dromedary which represent a kind of lipoma. In the cervico-thoracic hump of very fat animals fat may also occur, but it is usually distributed in layers, first subcutaneous, then between *M. trapezius* and *M. rhomboideus*, and finally beneath the latter (Curson and Bisschop, 1935). In the thoracic hump of animals in high condition there is a general infiltration of fat, which begins at the highest and hindmost part of the hump, then extends downwards, and finally forwards. Contrary to Curson and Bisschop's findings, Bettini (1940) describes three different structural types in the thoracic humps of southern Somali cattle: (1) Muscular, of a pale veal colour—the most common type; (2) muscular, of a bright red colour; (3) musculo-fatty, with a large quantity of fat and a light muscular framework—the rarest form. The present author recently examined several hundred longitudinally halved frozen humps of Eritrean and Ethiopian Zebu cattle. In the Ethiopian cattle the hump was all fat, on a foundation and in a framework of muscular and connective tissue which conveyed

* The earliest rock paintings in Abyssinia, from the Dire Dawa area, depict cattle with long horns and no humps, and must therefore antedate the introduction of the humped Zebu cattle from Asia (Cole, 1954).

the impression of complete adipose degeneration. The forequarters of the Eritrean cattle were exceedingly poor; in consequence, the muscular base and fibrous framework of the small humps were more apparent than in the well-covered Ethiopian forequarters; still, the humps retained a perceptible amount of fat, more especially in the uppermost posterior part, and not even in the leanest specimens did they warrant the term muscular instead of musculo-fatty. This is confirmed by Hornby's comments on the thoracic Zebu hump (Curson and Bisschop, 1935): "At birth the musculature is well marked, but as the animal develops this becomes more and more obscured by fat deposition. Even when the adult loses condition and the hump shrinks very greatly, the hump never regains the lean muscular state of calfhood—a certain amount of fat and fibrous tissue persist".

The Distribution of Zebu Cattle in East Africa

The area of distribution of Zebu cattle in East Africa extends from Bab el Mandeb south-eastwards along the coast of the Gulf of Aden and thence throughout Somaliland, and north-westwards along the Red Sea coast through Eritrea to the southern outskirts of the Nubian Desert and the eastern parts of the Anglo–Egyptian Sudan. In the Sudan the chest-humped Zebu has intermingled with humpless shorthorn and neck-humped Sanga cattle, resulting in numerous intergrading breeds and individuals. The Zebu is bred mainly by Arab nomads north of about the tenth parallel of latitude; south of this line the herds of the pagan Nilotics are of Sanga stock. In Ethiopia the majority of the cattle are of Zebu type. Sanga cattle are bred only in the north, near the Eritrean border, and in the south-west, contiguous with the breeding grounds of Sudanese long-horned Sanga.

From Eritrea and the Horn of Africa Zebu cattle have been taken southwards, mostly by Arab traders. In East Africa they are concentrated in a large area. In Uganda they occupy the Eastern and Northern Provinces, while in the Western Province Sanga cattle are bred. The Eastern Province pastures, stocked with Zebu cattle in greatest concentration, are low-lying *Combretum* savannas, the average altitude being approximately 3,500 ft. (Curson and Thornton, 1936).

In the Belgian Congo Zebu cattle are found north-west of Lake Albert, breaking the continuity of the Sanga line from Abyssinia to the northern end of Lake Tanganyika. Among the Mangbattu who dwell at the headwaters of the Uele, in the north-east of the Belgian Congo, Schweinfurth (1918) encountered pure Zebu cattle which Munsa, king of the Mangbattu, had received from a friendly ruler beyond the south-eastern border of his kingdom. They probably came from the vicinity of Lake Albert, which, in turn, they had reached from the Zebu country east of the Victoria Nyanza where Zebus of a similar type occur to this day.

In Kenya nearly all indigenous cattle are of Zebu stock. The various sub-types are named from the tribes breeding them: (*a*) Boran, in the Northern Frontier Province; (*b*) Kavirondo, in the south-west of Kenya; (*c*) Nandi, also in the south-west; (*d*) Akamba, in south-east Kenya; (*e*) Masai, in South Kenya.

The cattle of Tanganyika Territory are of two different types: the ordinary chest-humped Zebu and the neck-humped Ankole Sanga. It is estimated that the Ankole type constitutes less than one-fortieth of the herds of the country, the overwhelming majority of Tanganyika cattle being Zebu proper.

"In Tanganyika one could lay one's hands upon a very considerable number of what might almost be called distinct (Zebu) breeds, purely the product of environment," McCall (1928) writes. The best Zebus of Tanganyika Territory are met with in great numbers among the Masai, especially in the higher country around Ngorongoro and Balbal, where abundant salt deposits, perennial streams, sufficient rainfall, the presence of limestone in the soil, and clover in the grazing, make for more or less ideal ranching conditions. To this may be added the very important factor of an ample milk supply assured to the calves during their youth, as the Masai are a purely pastoral people and own large herds with the result that only a very little milk is taken from each cow (McCall, 1928).

From Tanganyika Territory Zebu cattle have been brought to Zanzibar and Pemba where they furnish meat, milk and draught power, the ox cart providing the most common form of transport.

In Nyasaland Zebu cattle, extending from the littoral, are gradually displacing the original Sanga stock of the country (Curson, 1936; Curson and Thornton, 1936). In the Central and Northern Provinces the cattle are

almost entirely of Zebu type (Faulkner and Brown, 1953). But quite pure Zebu herds are found only in Karonga district on the north-western shores of Lake Nyasa, where, owing to the surrounding Misuku and Nyika highlands, native migrations have been limited (Wilson, 1941).

Zebus are found also on the Tanganyika plateau and in the Fort Jameson district of North East Rhodesia where they are known as Angoni cattle.

In Mozambique the Zambesi forms a convenient line of demarcation between the Zebu to the north and the Sanga to the south, the Zambesi river being the southern limit of the distributional area of chest-humped Zebu cattle in Africa.

Characteristics of the East African Zebu Breeds

The Zebu cattle of East Africa display a marked lack of uniformity in conformation, as their ancestors entered the African continent in a long succession of waves of different origin, from countries as far apart as Arabia and India. In East Africa natural selection and adaptation to the different environmental complexes have added to their variability.

East African Zebus occur in every shade of colour encountered in domesticated cattle. There are red, brown and yellow animals, others white, black or silver grey, besides a great number that are variegated or speckled, or show other colour combinations.

In the majority the horns are relatively short, growing sidewards and upwards. In some specimens they are lateral or downward in direction; others again have loose horns devoid of cores, or one loose and one firm horn; and finally there are polled Zebus.

The development of the thoracic hump varies considerably. Some Zebu breeds, as the Mangbattu cattle, grow very large humps; in others, as the Somali cattle, the hump is of negligible size.

Faulkner and Brown (1953) roughly divide the chest-humped (short-horned) Zebu cattle of East Africa into a large and a small type. The large, believed to originate from the southern parts of Abyssinia and the arid hot areas of the Northern Frontier Province of Kenya, the Karamojo district of Uganda, and western Italian Somaliland, is called from the Boran of Kenya. The small type is bred mainly in the higher rainfall areas. Obviously, between these extreme types there are numerous gradations in size. Indeed, body size in East African Zebu cattle is not always a constant hereditary feature; it largely depends on the environmental conditions of the country and on the wealth or poverty of the pastoralists. In various areas Zebus may attain a live weight of 1,000 lb., whereas in the poorer cattle districts average specimens do not scale more than 350 to 400 lb. Some of the East African Zebus, such as the selected Boran of Kenya and the Singida, Iringa, Mkalama and Ugogo cattle of Tanganyika Territory, are large-framed beasts. On the other hand, the Wachagga cattle, on the slopes of Kilimanjaro, in close vicinity of the tsetse-fly belt, are dwarfed, light-boned and weedy, being kept under miserable conditions inside the dwelling-houses of their owners, and fed largely on banana leaves, couch grass and manioc, while the calves are consistently starved. In some areas the Zebus have acquired the browsing habit of goats and have grown so unaccustomed to grazing that, when moved to grass country, such animals invariably fall away in condition during the first few months (McCall, 1928). The occurrence of dwarf Zebu breeds in East Africa is, therefore, due mainly to an unfavourable environment which, operating through many generations, would reduce the offspring even of originally large cattle.

The influence of environment, and especially of nutrition, on size is illustrated by the fact that native Masai cattle average 240 to 400 lb. slaughter weight, while Masai cattle raised under European management average 450 to 500 lb. In Kenya, on a privately-owned ranch, improvement of environment within six years raised the slaughter weight of Boran steers, at five years of age, from 583 to 699 lb. on an average (Faulkner and Brown, 1953). The inadequacy of the food intake has been established as a cause of dwarfing in Northern Nigeria; growth in test animals was markedly improved by an increase of 2 lb. in the starch equivalent of the daily ration (Anderson, 1933). In Kenya, on the other hand, the small size of Zebu cattle in an area of excellent rainfall and apparently good pasture conditions is connected with low blood copper levels (Burdin, quoted by Faulkner and Brown, 1953).

In a hot, humid climate dwarfing in cattle, resulting in a larger body surface in relation to weight or volume of the body, facilitates heat dissipation. Also, metabolic heat production of the body is reduced by lack of appetite

and a low food intake, resulting simultaneously in a diminished growth rate and smaller body size.

The cattle of the Somali peninsula are generally small and unsightly, and of a similar type to those of southern Arabia, having in all probability been imported at a relatively recent date (Drake-Brockman, 1912). In all of them the hump is thoracic in situation. Commonly the horns are thin and short, rarely exceeding 20 cm. in length. However, the Jiddu or Surco Sanga of Italian Somaliland has horns up to 90 cm. long with a basal girth of 42 cm. Among the Zebu cattle of Somaliland many specimens are polled or have loose horns. In loose-horned cattle the horn sheaths are normally developed, but there are no cores to support them. In their stead very short rough elevations project from the skull. Such bony elevations are occasionally found also in polled animals. The occurrence of coreless horns is rendered possible by the different histological origin of sheaths and cores, the former being an appendage of the skin, the latter part of the cranial skeleton.

In Italian Somaliland four Zebu breeds are distinguished, in addition to the Jiddu or Surco Sanga: The Gasara, known also as the Aria and as "the little breed of the sand-dunes", is bred in various parts of the country, foremost in the coastal areas; the Gherra or Dauara, found chiefly in Ghel del Dafet, at the upper and middle course of the Webbe Shibeli, decreasing in number towards the lower Shibeli and Juba rivers; the Boran, bred by the Harti and Mohamed Zubier tribes in the more southerly districts west of the Juba river; the Singhi, at one time numerous in the Webbe Shibeli area, but now being absorbed by other breeds, notably the Gasara (Bozzi and Triulzi, 1953).

The Gasara is a small animal, with short horns, occasionally polled, a small dewlap, few skin folds ,and very variable coat colour. It is used mainly as a dairy animal, and responds well to improved management. The Gherra is large and of good conformation. With careful management the cows give more milk than those of any other native breed of Somaliland: in addition, the Gherra also dresses out well at slaughter. It stands 120 to 132 cm. at the withers, the anterior part of the rump being approximately 10 cm. higher. It has a convex facial profile, small firm or loose horns, occasionally none, long somewhat pendulous ears, a well developed dewlap, and small hump. The colour of the coat is a deep red. The Boran has a shoulder height of 118–124 cm. in the male, 108–120 cm. in the female. It is distinguished by the small head, straight facial profile, short to medium horns, and well-developed hump. The predominant colour is white. It is valued for its beef. The cows, at the height of lactation, produce 5 to 10 kg. of milk per day (Gadola, 1947).

In Eritrea two different Zebu breeds occur, the Araba and the Begait. The Araba is known also by the name of Bahari or Sea Cattle, a term referring to their origin from across the sea. On the coast belt and in Massawa the Araba is found in its purest racial form; sporadically it occurs also in other parts of Eritrea, but seldom pure bred. In type the Araba is practically identical with the Somali Zebu. It is a small or medium-size beast, its withers height varying between 110 and 130 cm., with a small thoracic hump, long convex head, and short fine horns, sometimes without horns. The colour of the coat is usually light-brown throughout, occasionally variegated. The skin is thin and elastic, the hair fine. The oxen are too small and weak to make good draught animals (Marchi, 1929).

Head of Begait Cow. After Marchi

The Begait is bred by the Barca and Beni Amer, in the northern parts of Eritrea. On the eastern foothills of the high plateau it has interbred with Aradò, a chest-humped Sanga breed, and with Araba cattle. The Begait is closely related to the Araba, but larger in body size, its withers height ranging from 135 to 145 cm. The head is long and narrow, especially the facial part, with a markedly convex profile and short horns; many specimens are polled. The ears are long and frequently somewhat pendant, the dewlap is moderately developed, and the thoracic hump fairly prominent. The legs are long, and the rump is drooping. The animals are usually lower in front than behind. The colour of the

coat is white, black-and-white and red-and-white, the coloured portions being fairly symmetrically distributed over the body. Begait cattle make poor draught beasts and, like the Araba, do not thrive in the cold climate of the high plateau owing to their thin hides and short coat (Gadola, 1947).

Zebu Cow from Eritrea. Photo: Dr. Y. S. Goor

The intermingling of the three major Eritrean breeds, viz. the Araba and Begait Zebus and the Aradò Sanga, has given rise to a considerable number of crossbreds. In fact, crossbreds are numerically superior to all pure-bred Eritrean cattle collectively. Among their great variety Marchi (1929) singles out the Baria of western Eritrea for its superior conformation and uniformity. It is a strong, large-framed beast, with thick horns of medium size and a slightly convex facial profile. The Baria is believed to be derived from a mixture of Begait Zebus and Aradò Sangas, but its conformation shows pure Zebu character.

From 1952 to 1955 the author inspected approximately 2,000 tons of frozen beef from Eritrea, derived from cattle slaughtered at Asmara, and shipped from Massawa. The average weight of forequarters was 77 lb., of hindquarters (without kidneys and kidney fat) 64 lb. The meat, more especially that of the forequarters, was for the greater part of a most inferior quality owing to the large share of connective tissue—fasciæ, tendons and ligaments—and the relatively small share and thinness of muscle. Hump development was poor. The percentage of bone averaged 22.5 per cent in forequarters, 19 per cent in hindquarters.

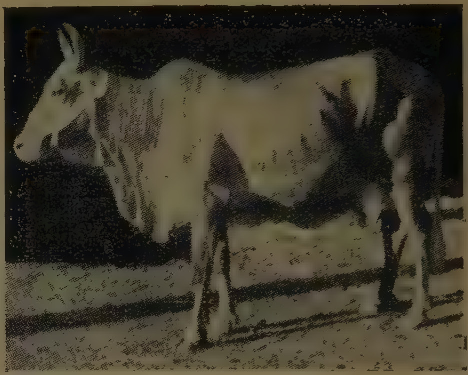
North and west of Eritrea, in the outskirts of the Nubian Desert and the westernmost part of the Anglo–Egyptian Sudan, chest-humped Zebus have interbred with neck-humped Sanga, chest-humped Sanga, and humpless shorthorn (brachyceros) cattle, presenting a great mixture of types. The humpless shorthorn type is in the minority; the majority of the cattle in the territories adjacent to Eritrea are humped, though there is but little uniformity in the shape, structure and situation of the humps.

Crossbreds from the Sudan. After Adametz

Several types of cattle exist in the Anglo–Egyptian Sudan, as might be expected in a territory of so vast an area. There is little doubt that in many districts these types are descended from cattle which in the not far distant past virtually constituted different breeds in the European sense of the term. Although their identity is becoming progressively lost as general freedom of movement increases, two main types, differing widely from each other, can be distinguished: a northern and a southern. The approximate boundary of demarcation between the two is formed by the rough east to west line which divides the northern Mohammedan from the southern pagan areas of human habitation. The northern or Arab cattle are of chest-humped Zebu type, the southern of either chest- or neck-humped Sanga stock. The negligible degree to which these two group types have mixed in historic times may be ascribed to the same causes that have kept the human inhabitants of the two areas equally distinct (Bennett, 1938). The differences between the two principal groups of Sudan cattle are more than merely morphological, since neither type thrives in the other's environment; a large proportion of the Zebu cattle will die if maintained in the south during the rains. The economic potentialities of the two types also differ; the Zebu does not generally reach the size and weight of the Sanga, but the Zebu cows are superior milkers (Bennett, John and Hewison, 1948).

The northern cattle of the Mohammedan areas of the Anglo–Egyptian Sudan have horns of medium size and well-developed humps. They show a relatively low degree of variability, although some differentiation within the main type has occurred in response to the varying environmental conditions. Generally, they are of the chest-humped Zebu type, although in some of them the cervico-thoracic situation of the hump suggests an earlier admixture of a neck-humped Sanga strain or of humpless cattle—in the crossbred progeny of chest-humped Zebu and humpless parent stocks the small hump is frequently cervico-thoracic. Bennett (1938) believes them to be derived from a cross of African humpless shorthorn-cattle and neck-humped Zebus, but Boyns (1947) has pointed out that this is quite improbable in view of their close similarity to Indian Zebus and the absence of conformational variability that would be expected among the descendants of a fairly recent cross between widely different types.

The cattle of the nomad pastoralists of the northern Sudan are represented by two types, the Kenana of the Fung area and the White Nile type. The name Kenana is taken from the semi-nomadic tribe which owns the major herds of this type (Hattersley, 1951). While the Kenana and White Nile cattle are similar in general conformation, size and late maturity, the Kenana, as a result of the more secluded nature of its habitat, approaches nearer to a separate breed than the White Nile cattle. In the latter, coat colour varies considerably, red, fawn, black, white and variegated specimens being common. On the other hand, the Kenana cattle, bred mainly in the Kenana and Rufaa districts of the Blue Nile Province, are very uniform in colour, which is commonly steel-grey, shading darker towards the extremities, and usually terminating in black points. The bulls are darker in colour than the cows. The calves, which are born brown, change to steel-grey after three to six months. The hair of the mature animals is short and wiry, and the skin black. The thoracic hump is well developed in animals in good condition. The horns are of medium size, curving inwards, occasionally inwards and downwards; frequently they are not attached to the cranium and swing freely. During the rainy season most of these cattle graze in the Jebel Moya area, as the southern reaches of the Blue Nile are then practically inaccessible owing to floods, flies and mosquitoes. Later, as the northern grazing grounds dry up, they return to the villages on the banks of the river, where most of the cows in milk or heavily in calf are left to provide the milk supply of the villagers. The remainder follow the receding vegetation southwards to the southern grazing grounds, comprised largely of low-lying swamps along the river banks, and finally return northwards when the rains start (Scott, 1947).



Cow of Shendi type, Northern Sudan. After Boynes

Among the cattle of the riverain areas of the Northern Province of the Anglo–Egyptian Sudan two types are distinguished, Dongola and Shendi. Both mature at an earlier age than the nomad cattle—three years as against between four and five. The Dongola cattle, bred in the irrigated areas of the extreme north, have been isolated from foreign blood for many generations; their predominant colour is red, with a few red-and-whites. Among the cattle of the Shendi district, which are believed to originate from the nomadic Butana cattle, red of different shades predominates. The cultivators of the irrigation lands select their breeding stock with a view to milk production, with the result that the Shendi cows are among the best dairy cattle of the Sudan (Boyns, 1947).

The Butana cattle, of the *Acacia* scrub country and desert between the Nile and its tributary, the Atbara, north of the 14th parallel, are red-coloured, of medium size, with prominent folds of loose skin under the brisket and belly, and a pronounced hump. They are distinctive among Sudan cattle in their general conformity to a good dairy type (Hewison, 1945).

A selected dairy herd of Kenana cattle is maintained at Gezira Research Farm, Anglo–Egyptian Sudan, and a similar herd of red Butana cattle was assembled at Shendi in 1943.

Zebu Cattle from Harrar, Ethiopia

In Ethiopia Zebu cattle are concentrated mainly in those parts which are contiguous with the breeding grounds of Zebus in Eritrea, Somaliland, Kenya and the Anglo–Egyptian Sudan. Thus in Amhara the principal breed, in addition to the Aradò Sanga, is the Begait Zebu (Nieri and Robotti, 1939). Again, in Galla and Sidamo nearly all cattle are humped; but they are of a mixed type, except in the vicinity of Harrar and towards the Kenya border where the Boran predominates (Roetti, 1939). In Shoa five different breeds of cattle are distinguished, Walega, Shoa, Arusi, Adal and Harrar (Girardon, 1939). Of these the Harrar, whose breeding centre is situated near the border of (British) Somaliland Protectorate, is a chest-humped Zebu breed of superior size and conformation, closely allied to the Boran of the Northern Frontier Province of Kenya, southern Ethiopia, western Italian Somaliland and the Karamoja district of Uganda (Pirani, 1938).

The author recently inspected over 1,000 tons of frozen beef from Ethiopia, shipped from Jibuti. The beef was derived from chest-humped Zebu cattle from Dire Dawa, Harrar and the western part of British Somaliland. The weight of forequarters was approximately 95 lb., of hindquarters (without kidneys and kidney fat) 77 lb. The meat, apart from the fat hump, was moderately lean but of good quality, with full muscles and fine bone; it was, however, rather tough, having been derived from mature to aged animals. The percentage of bone averaged 17 per cent in forequarters, 14.5 per cent in hindquarters.

On the healthy mountain pastures of northern and south-western Ethiopia the Sanga has been able to maintain its position, but in Uganda, Kenya and Tanganyika Territory, Zebus have to a large extent replaced the Sanga. In Uganda the Zebu is generally considered to be hardier and to possess greater power of resistance to certain diseases and such adverse conditions as poor grazing and fly infestation than the Sanga cattle. In particular, the Karamoja cattle, in the Eastern Province of Uganda, are credited with high resistance to drought. No cases of bovine tuberculosis were found in Uganda between 1919 and 1928, but thereafter the figures increased until, in 1935, 77 of 231 carcasses of Ankole Sanga cattle (33.3 per cent) and 49 of 7,848 Zebu cattle (0.6 per cent) were found to be diseased. In the Ankole cattle one-half of those diseased showed lesions in the thoracic cavity (Carmichael, 1939).

In Uganda the Zebu breeds vary markedly in size, the Karamoja cattle being large, the Western Nile, Teso, Lango and Sesse Island breeds small. They are generally short- or medium-horned, more rarely polled. In the hot low country between Mount Elgon and the Sudan to the north and to the east as far as Lake Rudolf many animals are distinguished by relatively large horns, with a peculiar uplift which gives the head a hartebeest appearance (Curson and Thornton, 1936). The cows are usually white, but the bulls have the back frequently grey-coloured. This would indicate complete or partial sex linkage of pigmentation in the silver-grey coat colour of Zebu cattle, a condition the author frequently observed in Zebu cattle from Iraq and Iran.

Zebu Bull of the Mangbattu, Belgian Congo.
After Schweinfurth

At Entebbe Stock Farm a small type Zebu herd was selected for milk production, and another herd of the same breed for beef. Herds of small Zebu cattle are maintained at Mbarara Livestock Farm and at the Serere Experimental Station.

North-west of Lake Albert, at the Upper Uele, in the Eastern Province of the Belgian Congo, the Lugwaret Zebu is bred by the Mangbattu and other tribes in their neighbourhood. Lugwaret cattle are small and thick-set, the withers height ranging from 95 to 125 cm.; they are of good conformation and various colours, the most common pattern consisting of small black, red or yellow patches on a white ground, often crowded on the flanks (Curson and Thornton, 1936). In the male the hump is sometimes of enormous size. From the end of the neck, it slopes upwards and backwards until it reaches and overhangs almost the middle of the back. There it does not slope down on to the back, but curves forwards for about one-third of its total length until it reaches the chine to which it is attached. The hump may be termed "loose", though it must be emphasized that anatomically it is nevertheless securely attached. Humps of this shape are frequent among East African Zebus. The head of the Lugwaret Zebu is long and very narrow. Above the eyes the forehead recedes towards the poll, enhancing the convex appearance of the profile. The horns are of medium length, slender, and attached to stalk-like necks, their direction being slightly backward and sideward, then upward, with the tips curved inwards. The neck is muscular. The dewlap extends from the throat to the chest. The body is compact and well covered, the back straight, and the rump but slightly sloping. The upper thighs show marked roundness, but lack depth of twist. The lower thighs are long and poorly muscled. The legs are thin, strong and sinewy, with clean joints. The tail is long, slender and firmly rooted.

According to Holm, the Zebu cattle of Kenya are similar in appearance to the Thar Parker and Scindi breeds of India. Although small differentiations appear in different districts, the various sub-types are definitely Zebu (Curson and Thornton, 1936). In the drier areas the cattle are commonly large, in the higher rainfall areas small. Largest among the Zebu breeds of Kenya are the Boran cattle of the Northern Frontier Province, their shoulder height varying from 115 to 127 cm. (these figures slightly exceed those given for

Nandi Cow, Kenya. After Faulkner and Brown

Boran cattle from Italian Somaliland), the body length, measured from point of shoulder to *Tuber ischii,* 93 to 108 cm., girth of chest 142 to 161 cm., and breadth of hips 39 to 46 cm. These are followed by the Nandi cattle, with a shoulder height of 115 cm., length of body 92 cm., heart girth 145 cm., and breadth of hips 38 cm. Then come the Akamba with a shoulder height varying approximately from 111 to 114 cm., length of body 78 to 96 cm., girth of chest 137 to 147 cm., and breadth of hips 33 to 40 cm. Very close to the latter are the Kavirondo, their shoulder height varying from 111 to 114 cm., body length 79 to 87 cm., heart girth 137 to 139 cm., the width of hips measuring 34 cm. on an average (Curson and Thornton, 1936). The Boran is generally considered one of the best beef cattle types in East Africa. The bull weighs 1,200 to 1,500 lb. liveweight, the cow 850 to 1,050 lb. The carcass yield of selected bullocks averages 57.8 per cent. A herd of selected Boran cows, under grazing conditions without supplementary feeding, produced an average of 1,675 kg. of milk per lactation, testing over 5 per cent butterfat. Nandi cattle are characterized by an extreme fineness of bone and pronounced dairy type conformation. The bull weights 700 to 900 lb., the cow from 450 to 750 lb. liveweight. Selected Nandi cows produce over 1,000 kg. of milk per lactation, with an average butterfat percentage of 6 per cent (Faulkner and Brown, 1953). The colour markings of the various sub-types are extremely mixed and include reds, greys, blacks, black-and-whites, red-and-whites, etc. The Boran sub-type is generally putty-grey with a fair proportion of black or red specimens.

The Zebu cattle of Tanganyika are of every imaginable shade and colour. The cattle of Sekenke, Mkalama and many parts of Singida

are in the great majority of cases white with dark skins, black tips to their tails and ears, and black spots on the extremities of the limbs. White is a very common colour among the cattle of the Wanyaturu of Singida and Mkalama; but farther south in Dodoma among the Wagogo herds black-and-whites and brown-and-whites predominate, whilst in Iringa and the Southern Province of Tanganyika red is the commonest colour encountered. In parts of Tanganyika the Zebus attain an optimum live weight of about 9 cwt.; while in the poorer cattle districts average specimens do not scale more than 350 to 400 lb. The hump may reach a height of 1 ft., and has a tendency to sag (Curson and Thornton, 1936).

Singida, one of the highest districts north of the Central Railway, has long been famous for its cattle, the most prevalent colour of which is silver-grey to white, with the brush of the tail, the skin, hoofs and muzzle black. The combination of a light coat and dark hide is highly favourable in equatorial countries with intense solar radiation: the light-coloured coat reflects both heat rays of relatively short wave-length and light rays, while the dark hide protects nerve and skin, and perhaps the general blood chemistry, from the injurious ultra-violet radiation. Singida cows are excellent milkers, and their type is so distinctive and reproduces itself so consistently that it is thought worthy of being regarded as a breed. While resembling the cattle of Boran on the Abyssinian border in many respects, they show more symmetry, but are not so large (McCall, 1928).

White Singida Ox. After McCall

"In the Iringa highlands, in the enzootic East Coast Fever country, nearly all the cattle are more or less deep red in colour. Large-framed animals of rather striking appearance, of late years their numbers have been sadly depleted by wars and disease. According to many of the old men, time was when all the cattle in Iringa, Uhehe and Njombe were of a uniform blood-red colour, and it has only been within comparatively recent years that importations from Ugogo have led to deterioration of the original strain. These cattle are rather indifferent milkers and more attention seems to have been paid to the size of their humps than to the shape of their rumps, but nevertheless as a hardy breed suited to the cold bleak uplands of the southern area their ability to stand up to the long, hard months of the dry season is undoubted" (McCall, 1928).

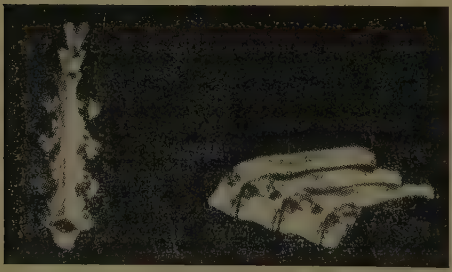
In the Mkalama district cattle of a deep golden dun colour are frequently encountered. The golden dun colouring tends to turn black at the muzzle, the brush of the tail, and the extremities of the legs. The skin is dark. Good specimens show well sprung ribs, are short of leg, and low to the ground. The milk from these animals is invariably rich (McCall, 1928).

In the drier regions of the Masai steppe and throughout Ugogo a peculiar type of Zebu is frequently met with. Its body colour varies from iron to steel-grey, but irregularly splashed upon this are areas of red or black. These animals breed exceptionally true to colour, and a peculiar feature is the frequency with which grey eyes are encountered. Of a large deep-framed conformation, they are credited by the dry area tribes with being particularly suited to inhospitable drought-stricken country (McCall, 1928).

Polled Zebu Oxen from Mbulu, Tanganyika Territory. After McCall

Generally, the Masai Zebus are distinguished by the small slender head, with short thick horns directed forwards, sidewards or upwards; occasionally polled specimens are encountered. The shape of the facial profile

depends on the weight and direction of the horns, i.e. their moment of rotation. The ears, of medium length, are directed laterally and slightly backwards. The neck is moderately long and furnished with a well-developed dewlap. The chine is broad, and the hump approximately 30 cm. high. In bulls the withers height may reach 140 cm., in cows 125 cm. The shoulder is oblique and well muscled, the chest relatively deep, but sometimes narrow; the belly is deep. The back and loins are straight and of medium length, the rump is weak and drooping, and the tail low-set, long and thin, ending in a full brush. The thighs are muscular, the legs rather short, slender and well-placed, with small, hard dark-coloured hoofs. The udder is small and fleshy, and the teats are short. The skin is thick and strong, covered with short smooth lustrous hair (Schroeter, 1914). As in other purebred Zebu cattle, the superior spines of the dorsal vertebrae from the sixth vertebra caudally are bifid, the tip being divided medially and also compressed antero-posteriorly.



Front and lateral views of the 7th–9th dorsal vertebra of Tanganyika Zebu Bull. From H. E. Hornby, after Curson

The selective breeding programme with four herds of Zebu cattle, i.e. White Singida, Red Iringa, Golden Dun Mkalama and Grey Ugogo, established at the Government Farm, Dar es Salaam, 30 years ago, has since been abandoned owing to the pressing demand for dairy products at Dar es Salaam, which involved the importation of dairy stock and the upgrading of local Zebus. A small herd of local Zebu cattle is still maintained at Moshi.

In Tanganyika Territory Zebus have proved definitely more useful than the Ankole Sanga; hardier, maturing earlier, better milking, better working and furnishing a superior carcass. The Zebu can adapt itself to almost every kind of vegetation community, and the limiting factors of its distribution in Tanganyika are neither climatic nor geophysical, but simply tsetse-fly belts (Curson and Thornton, 1936).

The Zebu cattle of Zanzibar and Pemba are small neat animals whose height at the hook bones averages 111 cm. The thoracic hump is pronounced; the horns are usually small and flat. The commonest colours are light red, dun, black and grey; roans and brindles are fairly frequent. Adult bulls weigh approximately 700 lb., cows 550 lb. A good cow will produce close to 700 kg. of milk in a lactation of one year. A herd of Pemba and Zanzibar stock is bred at the Kizimbani Experiment Station of the Zanzibar Department of Agriculture with the object of building up an improved strain of local Zebu cattle with high milk yields, disease resistance and draught power, and ability to thrive on local pasture without supplementary feeding for the greater part of the year (Tidbury, 1954).

Zebu Bull from Zanzibar

The Zebus of Nyasaland and the northern part of Mozambique, together with the Angoni cattle of North East Rhodesia, forming the southernmost branch of the chest-humped Zebu in Africa, resemble the Zebu cattle of Tanganyika Territory, but are more mixed in type and variable in conformation. Adjoining Sanga territory on the south, they are influenced by Sanga blood. In some specimens this is apparent in the cranial character, horn length and general conformation.

The Ngoni, a mixed people composed of Venda and Jena stocks from south of the Zambesi, and of conquered tribes from the Songea district of Tanganyika Territory and the Ngoni highlands, united under a ruling aristocracy of Zulu-Swazi origin, received their present breed of Zebu cattle at a relatively recent date. Originally their stock was of neck-humped Sanga type, closely allied to the Zulu;

but a century ago they lost all their beasts save two (according to the accepted tradition) in the tsetse-fly belt after crossing the Zambesi near Tete on their long trek from the south. Before finally settling in the Ngoni highlands in the Dedza and Ncheu districts of Nyasaland and the Villa Cortino division of Portuguese East Africa, they crossed the southern end of Lake Nyasa in the hope of renewing their herds. But they found no cattle until they reached Songea where they remained for a quarter of a century, fighting, raiding and building up the foundation stock of their present herds with which they returned to the Ngoni highlands in 1865, to lose about half their cattle again to British troops after the Ngoni war of 1896 (Read, 1938).

Herds of local Zebu cattle have been established at Chipazi in the Central Province, and at the Mbawa Government Farm in the Northern Province of Nyasaland. In Northern Rhodesia a herd of Angoni Zebus from Fort Jameson has been formed at the Government Research Station for selective breeding and comparison with Tonga and Barotse Sangà cattle.

The Origin of the Zebu Cattle of East Africa

The chest-humped Zebu is a comparative newcomer in Africa. It is not represented in ancient Egyptian records; in fact, its penetration into East Africa seems to have commenced only with the Mohammedan invasions.

In southern Babylonia the chest-humped Zebu replaced the original unhumped cattle at a much earlier date, namely, during the middle of the second millenium B.C., while a few specimens seem to have reached Sumer still earlier, as indicated by the occasional occurrence of this type on ancient seals and sculptures.

Zebu Bull from Southern Iraq

From the long interval of arrival in southern Babylonia and East Africa it may be inferred that the evolutionary centre of the Zebu lies, not west, but east of Mesopotamia. Additional evidence, thereof, is provided by the present distributional area of the Zebu in Asia, which includes nearly the entire southern part of the Continent, extending eastwards to the shores of the Pacific Ocean.

Chest-humped Zebus on a Babylonian Seal from the period of the Kassites (about 1500 B.C.)

Marshall (1931) has pointed out that the breeding centre of humped cattle was India, "from which country they were introduced into Elam at a very early date". In Assyrian times they were brought into Mesopotamia from the south, or "sea country" (King, 1915). In the shape of their horns and the lesser prominence of the hump these cattle differ somewhat from the Zebus on the ancient Indus valley seals (3rd millenium B.C.), which portray animals with large humps, thoracic in situation, and long sickle-shaped horns. "Although its original habitat has still to be found," writes Marshall (1931), "this type of bull can, for the present, be definitely associated with the Indus valley civilization, for though humped cattle appear in the art of other countries, they are never shown with the immensely long horns that they possess on the Indus seals". Adametz (1920) regards the northern and north-western parts of India as the birthplace of the Zebu, because India is the present centre of distribution of the type, with a large variety of different breeds.

From a geographical point of view this theory could be accepted, for the fringe of the Thar or Great Indian Desert represents the kind of environment that would favour the evolution of the desert type in domesticated animals, and would encourage cattle breeders to develop accumulations of reserve material in their domestic animals by the selection of appropriate breeding stock. Moreover, the present distribution of the chest-humped Zebu, as well as the chronological stages of its arrival at different localities, may well be quoted in support of the view that the evolution of this type took place in north-western India.

However, opposing evidence is not lacking: Col. Sewell believes that humped cattle were introduced into India from the west by some immigrating offshoot of the Mediterranean race (Marshall, 1931). Friederichs (1933) shares the view that India is not the original home of the Zebu. On seals from Mohenjo-daro and Harappa humpless long-horned and short-horned bulls are more frequent than humped bulls (Childe, 1935). When the Vedic Aryas invaded the Indus region, humpless cattle in the conquered territory were still superior in number to the Zebu. We read in Rig-Veda (VIII. 5, 37) that King Kaçu's herds included 10,000 straight-backed cattle and only 100 humped. Many recent Zebu breeds, such as the Bhagnari, Gaolao, Ongole (Nellore), Hariana and related forms, are believed to have entered India through the Bolan and other northern passes between 2200 and 1500 B.C., and to have spread along the route taken by the Rig-Vedic Aryan invaders from Kalat, Baluchistan, through Central India as far south as Madras (Olver, 1938; Ware, 1942). The archæological evidence so far available likewise suggests that the ancient Indus civilization received its first impetus from farther west (Forde, 1934).

From this it would follow that humped cattle reached the Indus valley from the west, and that the Thar or Indian Desert must be discarded as the original home of the Zebu cattle in favour of the steppe country on the fringe of the Helmand, Lut and Great Salt Deserts. This area cannot be considered as very well explored, and it is possible that future excavations will provide a clearer indication of the locality where the evolutional centre of the Zebu is to be found.

Marshall (1931) writes: "The evidence at present available suggests that humped cattle gradually made their way from Elam to Egypt, via Anatolia and Syria." But this is most doubtful, for records of humped cattle are not very plentiful in Anatolia and Syria, where shorthorn (brachyceros) cattle have been the prevalent type for more than 4,000 years. Nor are there any chest-humped Zebu breeds in Egypt.

On their way to Africa, the chest-humped Zebus, coming from India and Baluchistan, passed through the littoral of the Persian Gulf and southern Arabia, entering Africa at the Horn and the slave and ivory markets of the east coast.

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JOINT C.C.T.A./W.H.O. TRAINING COURSE ON RABIES

During the period 11th to 26th July, 1955, the above course took place at the laboratories of the East African Veterinary Research Organization at Muguga in Kenya.

The Inter-African Advisory Committee on Epizootic Diseases (I.A.C.E.D.) recommended that such a course to be held in Africa would serve a very useful purpose and negotiations commenced by the Inter-African Bureau of Epizootic Diseases (I.B.E.D.) in 1953 and approved by the Commission for Technical Co-operation in Africa (C.C.T.A.) resulted in acceptance by the World Health Organization (W.H.O.) of the application to participate by providing the discussion leaders.

The discussion leaders were Dr. M. M. Kaplan, Chief Veterinary Public Health Officer, W.H.O., Geneva, who directed the Course, Prof. Pierre Lepine, Chief, Virus Section, Pasteur Institute, Paris; Dr. Karl Habel, of the National Microbiological Institute, Bethesda, U.S.A.; Dr. Hilary Koprowski, of the Lederle Laboratories, New York; Dr. A. Komarov, Director of the Government Veterinary Laboratories, Haifa, Israel; and Dr. Perez Gallardo, of the School of Public Health, Madrid.

Thirty-eight veterinarians and medical officers were nominated by the Governments of the British, French and Portuguese territories in East and West Africa, the Belgian Congo, the Union of South Africa, the Federation of Rhodesia and Nyasaland, Egypt, Ethiopia, Lebanon and the Sudan. An English/French Interpreter was provided by C.C.T.A.

The Course was essentially a practical one in the latest laboratory techniques as applied to Rabies and the manual instruction was interspersed with frequent group discussions and lectures.

A short period of a few days towards the end of the course was devoted more particularly to field control.

A symposium on virus diseases to which many local biological research workers were invited was held on one afternoon during the course.

At a public ceremony, the course was opened by the Administrator of the East Africa High Commission.

I.B.E.D.

TRIALS OF FUNGICIDES FOR THE CONTROL OF DAMPING-OFF IN PINE SEEDLINGS

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Damping-off of pine seedlings in nursery seed beds of the Kenya Forest Department has been a consistent source of loss since the extension of pine planting (mainly *Pinus radiata* D. Don and *P. patula* Schl. & Cham.) in 1947. The great majority of such diseased seedlings, sampled from a number of nurseries in 1953, have yielded either *Rhizoctonia solani* Kühn or *Pythium ultimum* Trow. in culture. A range of these isolates has been tested for pathogenicity against pine seedlings grown in sterile sand with positive results, the test fungi being re-isolated from diseased tissues subsequently. Later, similar experiments have shown that this pathogenicity extends from the earliest stages of germination of the seeds until about the time when the seed cases are shed from the seed leaves, after which the seedlings become more resistant. This conforms with observations of Fisher and of Gravatt [4, 6]. Further indirect evidence to this effect has been obtained from the results of experiments where a close correlation was found to exist between pre-emergence losses and post-emergence damping-off.

Until 1953 some control of damping-off had been achieved by improved cultural methods, while potassium permanganate or Perenox were also applied to seed beds at times as fungicidal treatments, although neither had been tested in this capacity experimentally. The present series of experiments was started partly to evaluate these measures and also to explore the possibility of using other materials available on the market. The results obtained from the use of Perenox are included in this paper, while those for potassium permanganate have already been published [5].

Materials and Methods

The experiments described below were nearly all carried out on the premises of the East African Agriculture and Forestry Research Organization at Muguga, either in the glasshouse (approximate temperature range 36° C.–12° C. daily with a wide range of relative humidity), frame, or laboratory (approximate temperature range 20° C.–14° C. with relative humidities at 90 per cent and 60 per cent respectively). As a general rule conditions were adopted calculated to favour a high incidence of damping-off without departing too much from natural cultural conditions. Thus, normal forest soil has been used in plots which were kept well watered and to which seed bed soil known to contain *R. solani* and *P. ultimum* was added to the seed cover. Seeds of *P. patula* or *P. radiata* (about 80 per cent viable) were used as test plants, a high and constant rate of sowing being maintained. The plot units used have been either small wooden seed boxes, 7 in. by 8 in. and 5 in. deep, or pots of an impregnated paper preparation with a top diameter of 4 in. and depth of 5 in. Such units were laid out to randomized block designs for the comparison of five to six treatments at a time, replicated four to six times. Each experiment was brought to a close ten to fourteen days after emergence was complete when total numbers of dead and living seedlings were counted for each plot; these figures, in conjunction with the numbers of seeds originally sown per plot, were used to calculate percentage loss in the pre- and post-emergence phases and total seedling loss. Total loss and pre-emergence loss figures include that portion of the seeds which were not viable (about 20 per cent). These results were then analysed statistically for differences in seedling loss between treated and untreated plots, and where a level of significance has been obtained this is noted in tables according to the usual convention. Diseased seedlings were collected from untreated plots (and in special instances from treated plots) and plated out on 2 per cent malt agar at 26° C. for the determination of pathogens active in the experiment. It was found that pathogens were usually readily identifiable on plates after 24 hours' incubation in this way. A check was also maintained on the effects of treatments on soil pH using a glass electrode apparatus, and in certain experiments analysis for soil sulphate was also made. The latter has been possible, thanks to the assistance of Dr. P. R. Hesse, who carried out the analysis on acidified soil extracts using a turbidimetric method to measure sulphate precipitated from solution by barium chloride.

Materials discussed in this paper have been applied to the soil in all experiments as solutions or suspensions at a rate of 1 gallon per 2 sq. yds. weekly, the first application being at the time the seed was sown; rates of application have been adjusted with a view to costs as well as that of possible disease control. This method of application was regarded as most likely to be successful under Kenya nursery conditions, where regular watering of the seed beds is practised, often from sources liable to contamination. This is in contrast to conditions prevalent elsewhere, where soil moisture is largely supplied by rainfall, the reinfestation of a sterile seed bed is slow, and soil sterilization before sowing affords an effective means of seedling protection. A list of materials which have been on trial is given in Table I with details of properties. Most of these materials have been included in experiments in rotation in such a way that the group of materials varied in successive trials, each material being tested at least once under the various conditions used. Perenox has been tested an abnormally large number of times, as it was included in many experiments as a secondary standard for the assessment of new materials. Other materials mentioned in Table I have only been included in later supplementary experiments and are thus not mentioned in Table II.

Results

A summary of results obtained from comparative fungicide trials is given in Table II. No differences have been made out between experiments carried out under various environmental conditions or between the two test plants in use. Total seedling loss has been given as an index of disease control; this includes non-viable seeds sown but at the same time gives the best indication of the practical results that might be expected. It will be seen that, in general, compounds of the dithiocarbamate type have given the best record of disease control, followed by Perenox and organomercurial compounds. These will be discussed in detail below.

Perenox

This preparation has given somewhat variable results in the course of 21 experiments; in certain cases a very high rate of disease control has been obtained in contrast to others where little or no effect was obtained. A concentration of 0.3 per cent has proved to be optimal for control where it has been obtained, 0.15 per cent giving inferior results and 0.45 per cent little improvement on 0.3 per cent within one experiment. A comparison has also been made between this preparation and Yellow Cuprocide, also based on cuprous oxide, at rates of application giving equivalent dosage of active ingredient. The latter results indicated little difference between the two preparations, type of formulation having little effect on results. No phytotoxic effects were observed towards pine seedlings within the concentrations on trial.

In order to obtain more detailed information which might account for the variable results obtained from the use of Perenox, the toxicities of a range of concentrations of this fungicide were investigated in vitro towards isolates of *R. solani* and *P. ultimum*. A range of concentrations was made up in 2 per cent malt agar on to which mycelial inoculum of the two fungi was inoculated, cultures being incubated for 48 hours before growth measurements were made. The results of two such experiments have shown a considerable difference existed between levels of Perenox toxic to the two fungi, growth of *P. ultimum* being completely inhibited at a concentration of 0.005 per cent, while that of *R. solani* was only inhibited at 0.1 per cent. Such a difference might well account for irregular control effects such as were observed, results depending on the relative abundance of the two pathogens in a given experiment. Further evidence in support of this hypothesis has been obtained from an examination of the pathogens present in diseased plants from Perenox-treated and untreated plots out of nine experiments. Where Perenox had been applied an overall ratio of the occurrence of *R. solani* to *P. ultimum* stood at 1:0.29, while that for untreated plots was 1:1.09, indicating a much greater effect of Perenox in the control of *P. ultimum* than of *R. solani*.

Organo-mercurial preparations

Of the three organo-mercurial preparations tested only one has given a satisfactory record of disease control (Leytosol B.). Merculine, which has been tested most extensively, has given no control, even in a supplementary experiment where the strength of the dose had been raised in a comparable range to 0.6 per cent. This may be due to the alkaline effect of this material on the soil, which would tend to favour activity of the pathogens. There is no information relating to the extent to which

an oil emulsion preparation such as this is likely to restrict the dissemination of the active ingredient into the soil solution, but practical results suggest that this must be low. Granosan has given appreciable control effects in one experiment only. Phelam, a further compound combining characteristics of organo-mercurial and dithiocarbamate preparations, will be discussed separately.

Dithiocarbamate Preparations

This class of fungicide has given the most consistent results for the control of damping-off, Thiram and Dithane Z-78 (zineb) being most extensively tested. A more extensive experiment has been carried out in the nursery, under conditions similar to those of glasshouse experiments, in which several formulations of Thiram have been compared to Ziram and Dithane Z-78 (zineb). The results of this, given in Table III, show that Thiram has about the same activity in disease control, irrespective of formulation, and is slightly better than Dithane Z-78. This experiment was also large enough to obtain data on weed-control effects, which were pronounced for Thiram and Ziram. A similar effect of Thiram on weeds has been reported by Riker *et al.* [8] and Berbee *et al.* [1]. In the course of experiments mild phytotoxic effects were observed (particularly towards *P. patula* seedlings) to be associated with Thiram and Ziram treatments. These were characterized by a stunting and twisting of the rootlet which failed to penetrate the soil, the seedling lying on the soil surface. Only a proportion of the seedlings were so affected, indeed a very small proportion were sometimes found in untreated plots as well, suggesting that the Thiram or Ziram acted to accentuate an inherent weakness in certain seedlings. Results given in Table IV show a proportionate increase in these phytotoxic effects with increasing Thiram dosage. No such effects have been associated with Dithane Z-78, providing an interesting parallel to weed-control effects mentioned above.

Analyses for soil sulphate have been carried out on treated and untreated soils from experiments involving dithiocarbamate treatments. A set of results is given in Table III, showing a marked increase in soil sulphate following treatment with dithiocarbamate, while further results have shown soil sulphate to increase with dithiocarbamate dosage (Table VI). This effect may well arise from the decomposition of the preparations in contact with the soil, while on the other hand the sulphate may arise indirectly. With regard to the latter, evidence has been forthcoming elsewhere that dithiocarbamate compounds are more toxic to fungi than to bacteria. Should such a selective effect operate in the soil this may well lead to an increased activity of sulphur-oxidizing bacteria and an increase in soil sulphate. Further experiments have been carried out in which suspensions of dithiocarbamates have been allowed to percolate through columns of moist soil in glass tubes. Analysis of the effluent from these columns has shown a marked increase in sulphate in solution within one to two days of application, which would tend to support the possibility that the sulphate is derived from decomposition of the dithiocarbamate rather than from indirect bacterial action, which might be expected to take longer. Tests carried out on the original dithiocarbamate suspensions show no sulphate to be present in solution.

As the possibility existed that dithiocarbamates might decompose rapidly in contact with the soil, the activity of certain compounds likely to arise as intermediate decomposition products of Thiram or Crag 5400 have been investigated with respect to disease control. Experiments have been carried out in which elementary sulphur, neutral sulphate, dimethylamine, carbon disulphide and paired combinations of these have been compared in equivalent dosages to Thiram or Crag 5400 for disease control and phytotoxic effects. No comparable effects were observed except where dimethylamine and carbon disulphide were applied together (Table V), when disease control, phytotoxicity, and resultant soil sulphate similar to that of Thiram and Crag 5400 were obtained. This result is in agreement with those of Dimond and Horsfall [3] who observed that these two compounds exerted a synergy in toxicity trials, and with the suggestions of Parker-Rhodes [7] and Cox *et al.* [2] to the effect that dithiocarbamate compounds exert their fungistatic effects in a dissociated state.

Phelam

This preparation, combining the characteristics of an organo-mercurial and a dithiocarbamate, has shown fairly good disease control as a 3 per cent formulation when compared with Dithane Z-78 (65 per cent formulation); indeed, at equivalent rates of active ingredient Phelam proves to be markedly superior (Table VI). A more detailed comparison has

been carried out along these lines in which Phelam has been compared at equivalent rates of active ingredient to Leytosol B, Thiram, and a combination of Leytosol B and Thiram. The results clearly show that the activity of Phelam lies in the range of the organo-mercurial group rather than that of dithiocarbamate; this is confirmed in a third experiment, also given in Table VI.

Crag 658

Although Crag 658 has shown a good record of disease control when applied as a suspension of 0.20–0.25 per cent, phytotoxic effects towards *P. patula* have been observed. These are characterized by a stunting and browning of the rootlet, sometimes with forking, slight clubbing, and a general failure to penetrate the soil.

The severity of these effects has varied considerably between experiments and appears to be subject to environmental conditions not yet made out. However, in one experiment in which a range of concentrations of Crag 658 was compared, adequate disease control was obtained from concentrations at 0.2 per cent, while severe phytotoxic effects were evident at 0.4 per cent. Such a narrow margin of safety would be undesirable in the field.

Conclusions

The sum of these results has clearly indicated that the dithiocarbamate type of preparation is most likely to be successful as a preventative for damping-off under field conditions. Perenox may well prove unreliable on the face of the present evidence, while organo-mercurial preparations, as they are generally formulated on a basis of less than 10 per cent active ingredient, do not appear to be likely to give a good standard of control. It is quite possible that organo-mercurials might be most effective if applied at higher rates, but this would prove to be uneconomical.

The present experiments should not be regarded as presenting conclusive evidence that dithiocarbamate preparations will be effective in disease control over the wide range of conditions in Kenya nurseries; indeed, field trials already carried out have indicated that, while effective in the field under temperature and moisture conditions comparable with those of glasshouse trials, dithiocarbamate preparations may well be ineffective under colder, wetter conditions. At the time of writing, Dithane Z-78 has been considered to be most suitable for extensive field trial for reasons of cost, standard of disease control already observed, and absence of phytotoxic effects; other compounds mentioned above will also be tried simultaneously.

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TABLE I.—MATERIALS TESTED FOR THE CONTROL OF DAMPING-OFF IN PINE SEEDLINGS

Common Name	Active Ingredient		Reaction of suspension (pH)	Reaction of soil after treatment (untreated soil pH 6·8)	Remarks
Perenox	Cuprous oxide	50%	6·9	No change	
Cuprocide	Cuprous oxide	80%	6·8	No change	In one experiment only.
Granosan	Ethyl mercury phosphate	5%	7·0	No change	
Merculine	Phenyl mercury salicylate	10%	8·0	7·2—7·4	Emulsifiable oil solution.
Leytosol B	Phenyl mercury acetate..	3%	7·9	No change	
Thiram	α, α′ dithio bis (N-dimethylthio formamide) ..	97%	6·8—7·2	No change	63%, 50%, 18%, preparations dispersible, others not readily dispersible.
ditto	ditto	80%			
ditto	ditto	63%			
ditto	ditto	50%			
ditto	ditto	18%			
Dithane Z-78 (Zineb)	Zinc ethylene bis dithiocarbamate	65%	7·4	No change	
Ziram	Zinc dimethyl dithiocarbamate	63%	7·3	No change	Three experiments only.
Crag 5400	α, α′ trithio bis (N-dimethylthio formamide) ..	75%	7·0	No change	
Phelam	Phenyl mercury dimethyl dithio carbamate ..	3% & 10%	6·9	No change	
Crag 658	Copper zinc chromate complex	95%	7·1	No change	

TABLE II.—SUMMARY OF TESTS OF FUNGICIDES FOR THE CONTROL OF DAMPING-OFF IN PINES

Material	Suspension Used (Per cent)	Mean Total Seedling Loss (Seed Viability 80%) Per Cent		Total number of experiments	Number of Experiments in which a Significant Degree of Control was Obtained	
		Treated	Untreated		5% level (*)	1% level (**)
Perenox ..	0·30	41·7	61·5	21	4	2
Granosan ..	0·30	46·9	63·4	4	1	0
Merculine ..	0·15	63·1	65·7	8	0	0
Leytosol B ..	0·30	54·4	70·9	5	2	2
Thiram 97% ..	0·30	35·1	58·4	12	3	3
Thiram 18% ..	0·30	52·9	63·1	6	2	0
Thiram 18% ..	0·60	56·4	71·7	6	0	2
Dithane Z-78..	0·20	38·4	58·7	8	2	2
Dithane Z-78..	0·30	42·6	68·6	7	1	3
Crag 5400 ..	0·20	41·1	75·0	5	1	3
Crag 5400 ..	0·40	38·0	79·0	3	0	2
Phelam 3% ..	0·30	65·1	82·8	4	1	1
Phelam 10% ..	0·30	43·2	74·6	3	2	1
Crag 658 ..	0·20—0·25	35·0	61·4	9	1	4

TABLE III.—THE EFFECTS OF A RANGE OF DITHIOCARBAMATE PREPARATIONS AS SOIL TREATMENTS FOR THE PREVENTION OF DAMPING-OFF IN PINE SEEDLINGS AND ON WEED CONTROL. HOST PLANT: *P. patula*

Preparation	Strength of active ingredient applied (per cent)	Post-emergence loss (Damping-off per cent)	Total Seedling loss (per cent)	Weeds per sq. ft. (1 week after emergence of pine seedlings)	Final soil sulphate content (p.p.m.)
Thiram (80% wettable powder)	0·24	2·18**	53·3*	44*	235
Thiram (63% dispersible cream)	0·24	0·98**	51·6*	31*	166
Thiram (50% dust in water) ..	0·24	0·73**	55·8*	29*	241
Thiram (50% dust applied dry)	—*	2·19**	53·2*	58*	280
Ziram (63% dispersible cream)	0·24	0·26**	51·5*	27*	139
Dithane Z-78 (65% zineb dispersible powder)	0·20	3·34**	49·4*	80	19
Nil	—	29·22	69·3	87	0

*Thiram dust applied at 5·4 g. per sq. yd., equivalent to rate for aqueous suspensions of thiram.

TABLE IV.—A COMPARISON OF THIRAM AND ZINEB PREPARATIONS FOR CONTROL OF DAMPING-OFF AND PHYTOTOXIC EFFECTS IN PINE SEEDLINGS. HOST PLANT: *P. patula*

Strength of suspension and material		Damping-off (post-emergence loss) (per cent)	Total seedling loss (per cent)	Seedlings showing phytotoxic effects (per cent)
Dithane Z-78 (65% zineb) ..	0·20%	8·4**	39·8**	1·8
	0·40%	4·8**	32·2**	1·1
	0·60%	4·4**	36·9**	0·8
Thiram (63% dispersible cream)	0·15%	13·6**	44·3**	4·4
	0·30%	2·2**	32·8**	11·2
	0·60%	0·0**	26·6**	13·4
Nil	—	47·9	71·4	1·7

TABLE V.—COMPARISON OF DITHIOCARBAMATE DIMETHYLAMINE AND CARBON DISULPHIDE IN THE CONTROL OF DAMPING-OFF IN PINE SEEDLINGS AND IN PHYTOTOXICITY. HOST PLANT: *P. patula*

Treatment and strength of solution or suspension applied		Damping-off (per cent)	Phytotoxic effects	Resultant Soil Sulphate state of bed (p.p.m.)
Dimethylamine	0·11%	58·5	Absent	0
Carbon disulphide	0·19%	67·6	Absent	trace
Dimethylamine .. .. .. Carbon disulphide	0·11% 0·19%	10·2**	Present	381
Crag 5400	0·22%	0·3**	Present	456
Thiram (63%)	0·29%	6·1**	Present	453
Nil	—	61·2	Absent	0

TABLE VI.—THE RESULTS OF EXPERIMENTS COMPARING PHELAM WITH ORGANO-MERCURIAL AND DITHIOCARBAMATE FUNGICIDES FOR THE CONTROL OF DAMPING-OFF IN PINE SEEDLINGS. HOST PLANT: *P. patula*

Treatment and strength at application (per cent)		Strength of active ingredient applied (per cent)	Damping-off (post-emergence) (per cent)	Final soil sulphate (p.p.m.)
EXPERIMENT 1				
Dithane Z-78 (65% zineb) ..	0·05	0·033	12·1	29·6
	0·10	0·065	2·3*	163·2
	0·20	0·130	1·1*	240·0
Phelam (3%)	0·30	0·009	0·7*	—
	0·60	0·018	0·9*	—
	0·90	0·027	0·9*	—
Nil	—	—	14·4	17·4
EXPERIMENT 2				
Leytosol B	0·75	Dosages adjusted to give equivalence of mercurial or dithiocarbamate moiety	15·5**	—
Phelam	0·90		9·9**	—
Thiram	0·021		38·3	—
Ziram	0·025		35·8*	—
Leytosol B plus Thiram	0·75 / 0·021	—	22·3**	—
Nil	—	—	47·3	—
EXPERIMENT 3				
Leytosol B	0·15	·0027 (Hg)	3·1**	—
	0·30	·0054 (Hg)	0·5**	—
	0·45	·0081 (Hg)	1·1**	—
Phelam (3%)	0·15	·0023 (Hg)	9·0*	—
	0·30	·0046 (Hg)	3·6**	—
	0·45	·0069 (Hg)	0·5**	—
Nil	—	—	32·5	—

TENTH INTERNATIONAL CONGRESS OF ENTOMOLOGY

Montreal, Canada, 1956

The Tenth International Congress of Entomology will be held in Montreal on 17th to 25th August, 1956. Following the Congress a number of excursions to places of entomological interest will be arranged.

All those hoping to attend the Congress and wishing to obtain further information should communicate as soon as possible with the Secretary, Mr. J. A. Downes, Division of Entomology, Science Service Building, Ottawa, Ontario, Canada.

THE MAJOR AND TRACE ELEMENT COMPOSITION OF SOME EAST AFRICAN FEEDINGSTUFFS

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In the experimental work being carried out on the Muguga Farm of the Joint Division of Animal Industry of the East African Agriculture and Forestry Research Organization and the East African Veterinary Research Organization, a variety of feedingstuffs is being used, and a knowledge of their mineral composition was desired. As these feedingstuffs represent a typical cross-section of those in use in East Africa, it was felt that publication of the data would be of benefit to other users. Of the 18 samples analysed, 15 were obtained from commercial sources, while the remainder, beans, barley and lupin were the produce of the Muguga Farm.

The major constituents, potassium, calcium, magnesium, phosphorus and sodium, are expressed on a dry matter percentage basis and are shown in Table I, while the trace elements (Table II), copper, manganese, iron, strontium, barium, chromium, cobalt, nickel, zinc, titanium, silver, molybdenum, vanadium, tin and lead, are recorded as parts per million of dry matter. In all cases, the concentration given is that of the metal, not the oxide, in accordance with modern practice.

As little is known of the origin of most samples, the concentrations can only be taken as a guide to the mineral and trace element composition, and in some cases the presence of impurities has caused errors, this being particularly true of the lucerne sample. Some comparisons have been made to other data for similar materials from various sources, but there has been no attempt to make an exhaustive survey of the literature, either from the point of view of the actual contents of the materials or their significance.

Major Elements

Potassium.—The potassium content of the samples seems to be generally similar to the results obtained by other workers. The figures quoted by Woodman (1952) are of much the same order, for example, barley 0.47 per cent, beans 1.06 per cent, cotton-seed cake 1.33 per cent, groundnut cake 0.91 per cent, maize 0.33 per cent, oats 0.46 per cent, meat meal 0.58 per cent, but pure meat meal is given as 0.08 per cent K. Earlier data for East African feedingstuffs (Imperial Bureau of Animal Nutrition, 1936) indicate 1.5 per cent K for beans and 0.41 per cent for maize, the latter figure being a little higher than that for the current sample.

American data published by Henry and Morrison (1928) are also comparable, viz.: beans 1.14 per cent, cottonseed cake 1.5 per cent, linseed cake 1.05 per cent, maize 0.33 per cent, oats 0.47 per cent and the similarity is

Table I.—Major Elements in East African Feeding stuffs—1955
(*Percentage on a dry matter basis*)

	K.	Ca	Mg	Na	P	Ash
Barley	0·43	0·033	0·12	0·008	0·23	1·9
Beans	1·43	0·22	0·26	0·002	0·32	3·8
Bloodmeal	0·26	0·27	0·01	0·44	0·15	4·8
Bran (coarse)	0·85	0·20	0·50	0·010	0·63	5·9
Bran (fine)	1·03	0·13	0·52	0·006	0·31	4·6
Bulrush Millet	0·42	<0·02	0·18	0·002	0·31	2·4
Cottonseed cake	1·26	0·15	0·31	0·014	0·87	7·3
Groundnut cake	1·08	0·12	0·51	0·005	0·51	5·8
Linseed cake	0·74	0·24	0·68	0·026	0·50	4·4
Lucerne	2·30	1·88	0·42	0·29	0·24	22·7
Lupin seed (Giant White)	0·75	0·33	0·28	0·011	0·25	3·2
Maize (White)	0·28	0·033	0·13	0·003	0·21	1·0
Meat meal	0·50	0·97	0·10	0·78	0·40	6·6
Molasses	2·56	1·30	0·25	0·075	0·06	10·0
Oats	0·46	0·12	0·13	0·003	0·16	4·4
Pollards	0·97	0·15	0·44	0·004	0·44	4·3
Rumenal Contents	0·44	1·22	0·16	1·49	0·66	8·3
Yeast	0·81	0·25	0·26	0·010	0·33	3·5

further supported by the values given in a review by Beeson (1941).

Sen (1952), in his table of Indian cattle foods, quotes barley as containing 0.46 per cent K, bran 1.21 per cent, groundnut cake 1.19 per cent, and linseed cake 0.76 per cent, again very similar to the contents given in Table I. Bertrand and Rosenblatt (1928) obtained a figure for oats of 0.28 per cent K.

Calcium.—In general the figures given in Table I are comparable to those obtained from the same sources as given under Potassium, with the exception of bloodmeal and meatmeal. Woodman giving 0.036 per cent and 0.29 per cent respectively, these being low. The range of values given by Beeson for barley is 0.015–0.15 per cent, for beans 0.07–0.28 per cent, for maize 0.006–0.045 per cent and for oats 0.05–0.19 per cent. Sen quotes for barley the somewhat higher minimum of 0.06 per cent.

Magnesium.—Woodman does not quote the magnesium contents of the feedingstuffs, but close agreement is obtained with American and Indian figures, Sen giving for barley 0.13 per cent, groundnut cake 0.33 per cent, linseed cake 0.59 per cent and bran 0.45 per cent.

Sodium.—In the samples where it has been possible to obtain a comparison, the sodium contents of the East African feedingstuffs are very much lower than those from other sources. This is undoubtedly a reflection of the very low sodium content of most East African soils, but the magnitude of the difference is worthy of special note (*see* Table III).

It would appear that sodium occupies a role more of a trace element than a major constituent of plants in East Africa. Bertrand and Rosenblatt (1928) obtained a value of 0.005 per cent Na. in oats, this being of the same order as the East African value.

Phosphorus.—The phosphorus contents of the current samples seem to be rather low when compared to the general run of earlier data, but where a wide range of analyses is quoted by Beeson (barley, beans, maize and oats) the East African samples fall within the range. The figures given by Woodman, Henry and Morrison, Beeson (average) and Sen show a closer agreement among themselves, e.g. barley approximately 0.4 per cent, bran 0.9–1.3 per cent, maize 0.3–0.4 per cent, oats 0.3–0.4 per cent. Woodman gives a value of 2.4 per cent for yeast, over six times the content of the present sample.

TRACE ELEMENTS

It is believed that the trace element values quoted in Table II are the first to be published for East African materials, except for special investigations concerning one or two elements in a specific type of crop. The importance of trace elements in East Africa is still very much of an unknown quantity, and it is hoped that now the spectrochemical laboratory is established at Muguga, work will proceed on suspected problems in conjunction with Territorial Departments.

Barium.—The barium contents of the feedingstuffs cover the range from 2 to 55 p.p.m. and there are few data available for comparison. For beans, Robinson, Whetstone and Edgington (1950) quote 3 p.p.m., for oats 18 p.p.m. and maize 9 p.p.m., the first being low and the last high when compared to Table II. Gaddum and Rogers (1936) quote 10–15 p.p.m. for cottonseed cake.

Chromium.—It has not been possible to locate any data for comparable materials in the available literature and it is hoped to carry out a more thorough investigation at a later date.

Cobalt.—This element has considerable importance in animal nutrition, being an essential component of Vitamin B_{12}, a deficiency of which can cause anæmia and other disease. The bulk of the research work has been carried out on pastures, and figures for feedingstuffs are difficult to locate. Ahmad and McCollum (1939) give the values of 0.18 p.p.m. for beans and 0.06 p.p.m. for maize, while G. Bertrand and Mokragnatz (1930) found 0.01 p.p.m. in maize. Kidson and Maunsell (1939) found 0.01–0.04 p.p.m. in oats.

Copper.—This is another important element in animal nutrition and several diseases are attributed to copper deficiency in pastures and feedingstuffs. The copper contents as given in Table II compare favourably with those published by other workers, thus Elvehjem and Hart (1929) found 4.5–14.8 p.p.m. in lucerne, 7.2 p.p.m. in barley, 13.1 p.p.m. in bloodmeal, 4.5 p.p.m. in maize, 21.8 p.p.m. in cottonseed meal and linseed meal, 6.8 p.p.m. in oats and 16.4 p.p.m. in bran. Holland and Ritchie (1941) quote for maize 5–15 p.p.m., barley 15 p.p.m., oats 12 p.p.m., linseed meal 31 p.p.m., cottonseed meal 27–29 p.p.m. and bloodmeal 11 p.p.m. In culture experiments Piper (1942) found 1.8–3.0 p.p.m. Cu in oats according to whether or not copper was added

TABLE II.—TRACE ELEMENTS IN EAST AFRICAN FEEDING STUFFS—1955

Parts per million on a dry matter basis

	Ba	Cr	Co	Cu	Fe	Pb	Mn	Mo	Ni	Ag	Sr	Sn	Ti	V	Zn
Barley	2·2	0·87	<0·04	10·1	81	1·5	34	0·74	0·34	0·11	2·9	0·17	6·8	0·26	28
Beans	22	0·80	0·33	8·2	124	1·3	22	5·0	4·4	0·08	32	0·24	20·7	0·44	23·3
Blood meal ..	9·1	1·4	<0·10	4·9	1,800	3·8	9·3	0·02	0·41	0·17	10	0·31	12·6	0·49	14·9
Bran (coarse) ..	26	3·0	0·17	17·4	515	3·3	350	1·4	1·9	0·15	13	0·32	288	2·2	114
Bran (fine) ..	23	0·86	0·14	17·8	173	1·8	310	0·90	2·1	0·14	11	0·62	3·7	<0·14	34
Bulrush Millet	2·0	0·71	0·14	9·3	305	1·1	37	1·1	1·0	<0·05	1·2	0·10	83	1·2	26
Cottonseed cake	6·8	2·1	0·26	20	370	1·7	25	4·0	2·0	<0·09	42	0·13	34	0·86	30
Groundnut cake	9·9	3·1	0·29	18·4	625	0·90	55	7·8	5·1	<0·25	13	0·80	78	3·0	19·8
Linseed cake ..	2·8	0·74	0·078	22	192	1·2	47	0·85	1·9	0·26	136	0·11	16·9	0·23	34
Lucerne ..	30	4·0	0·63	13·7	4,750	8·8	180	12·1	2·1	0·85	140	1·4	435	8·6	71
Lupin seed (Giant White)	6·1	2·2	0·36	12·9	121	3·0	6,900	c300	5·0	1·6	9·5	5·8	5·7	1·2	40
Maize (White)	0·9	0·76	0·069	2·4	119	4·7	9·5	1·1	0·36	<0·04	0·9	0·16	12·2	1·2	38
Meat meal ..	60	2·4	<0·09	13·6	1,160	2·3	75	0·90	0·43	0·21	52	0·24	83	1·1	56
Molasses ..	21	1·4	0·076	5·5	900	0·96	80	0·45	0·43	0·30	47	1·8	4·5	0·33	11·5
Oats	13	0·74	<0·04	4·6	115	3·4	122	0·69	2·1	0·10	6·3	0·40	13·6	0·36	21·0
Pollards ..	29	0·55	<0·04	19·7	142	1·4	290	0·51	1·5	0·12	14	0·22	1·8	0·04	64
Rumenal Contents ..	55	13·9	0·92	6·7	3,250	21·4	118	6·5	2·1	0·48	107	1·36	>820	4·0	47
Yeast	8·8	0·76	0·15	8·3	224	2·8	77	1·8	2·4	0·11	15	0·84	6·0	0·62	243

to the nutrient solution, and Teakle and Turton (1943) found from 1–30 p.p.m. in oats and 5–9 p.p.m. in barley. However, earlier work by Vedrodi (1896) alleges much higher contents in various seeds; barley 10–120 p.p.m., beans 110–220 p.p.m., lupin 70–290 p.p.m., maize 10–90 p.p.m. and oats 4–51 p.p.m., but it is likely that the analytical method of that time was not as accurate as present-day methods.

Iron.—While there is usually an adequacy of iron in feedingstuffs, deficiency diseases have been known to occur, and also chlorosis in plants has resulted from lack of iron. The Muguga figures are in general slightly higher than those obtained by Holland and Ritchie, who give for maize 30–50 p.p.m., barley 57 p.p.m., oats 74 p.p.m., Cottonseed meal 150–280 p.p.m., but for linseed meal and blood-meal they give higher values, viz.: 1,087 p.p.m. and 4,524 p.p.m. respectively. Peterson and Elvehjem (1928) quote 58 p.p.m. for barley, 25.31 p.p.m. for maize, 89 p.p.m. for oats and 88 p.p.m. for bran. In Indian materials Sahasrabuddhe and Lele (1936) found rather lower contents; bran 77 p.p.m., groundnut 320 p.p.m., linseed cake 61 p.p.m., cottonseed cake 96 p.p.m. and maize 3.5 p.p.m. For white lupin seeds Maguenne and Cerighelli (1921) quote 98 p.p.m., which is very similar to the Muguga figure. The Imperial Bureau of Animal Nutrition (1938) publish data including 41 p.p.m. Fe in barley and 42 p.p.m. in oats.

Lead.—No comparative figures as yet available.

Manganese.—This element has received a great deal of attention, due to its importance in plant and animal physiology. In the work of Holland and Ritchie, maize is quoted as having 5–18 p.p.m., barley 7 p.p.m., oats 20 p.p.m., linseed meal 35 p.p.m. and cottonseed meal 16–19 p.p.m., these being similar to the present series, except for the low figure for oats. The value for barley is also somewhat low, but reference to Beeson's review gives 7–38 p.p.m. for barley and 23–76 p.p.m. for oats.

Molybdenum.—To molybdenum is attributed the property of participating in the fixation of atmospheric nitrogen by plants, but an excess is known to cause disease, for example "teart". D. Bertrand (1939) found 1.0 p.p.m. in maize, 0.35 p.p.m. in oats and 4.5 p.p.m. in beans, but much higher contents were found by Barshad (1948), 5.4 p.p.m. in barley and 2.0 p.p.m. in oats, and Robinson and Edgington (1948) 9.2 p.p.m. in oats and 8.4 p.p.m. in maize. A remarkable figure in the Muguga samples is the presence of 300 p.p.m. Mo in the lupin sample.

Nickel.—G. Bertrand and Mokragnatz found 0.14 p.p.m. in maize, a value of the same order as the Muguga figure, but their figures for beans, 0.59 p.p.m., and oats, 0.45 p.p.m., are much lower.

Silver, Strontium, Tin.—No comparative figures are as yet available.

Titanium.—Beeson, quoting the values obtained by G. Bertrand and Veronca-Spirt (1929) gives 0.9 p.p.m. for barley, for maize 1.4 p.p.m. and oats 1.3 p.p.m., all of these being much lower than the present series.

Vanadium.—Few data are available for this element, but D. Bertrand (1941) found oats to contain 0.35 p.p.m. and beans less than 0.02 p.p.m., the former comparing closely with the figure in Table II, but the latter is much lower.

Zinc.—This element has received some attention in connexion with plant nutrition and G. Bertrand and Benzon (1929) are quoted by Beeson as finding 21 p.p.m. in barley, 23–56 p.p.m. in beans, 20 p.p.m. in maize and 22 p.p.m. in oats. Teakle and Turton found 16–53 p.p.m. in oats and 14–17 p.p.m. in barley, and Holland and Ritchie found 21–34 p.p.m. in maize.

TABLE III.—SODIUM CONTENTS OF SOME FEEDING STUFFS FROM VARIOUS SOURCES

(*Percentage on Dry Matter Basis*)

	East Africa (from Table I)	U.S.A. (Henry & Morrison)	U.S.A. (Beeson)	India (Sen)
Barley	0·008	—	0·03 —0·15	0·04
Beans	0·002	0·074	0·01 —0·38	—
Bran	0·006—0·010	0·18	—	0·26
Cottonseed cake ..	0·14	0·26	—	—
Groundnut cake ..	0·005	—	—	0·24
Linseed cake ..	0·026	0·25	—	0·35
Lupin seed	0·011	—	0·10 —0·16	—
Maize	0·003	0·03	0·001—0·125	—
Oats	0·003	0·17	0·01 —0·23	—

METHODS OF ANALYSIS

Potassium.—The ash of the sample was extracted with hydrochloric acid and the extract evaporated to dryness. The residue was taken up in 0.05 N. hydrochloric acid and the solution used in the Lundegardh flame spectrochemical method.

Phosphorus.—The sample was dissolved in nitric acid–perchloric acid mixture and the phosphorus determined colorimetrically as molybdivanadophosphate using the Spekker photoelectric absorptiometer.

Calcium, Magnesium, Sodium, Barium, Copper, Iron, Manganese, Strontium.—These elements were determined spectrochemically using the method of Farmer (1950) in which the ash of the sample is burned in a carbon arc with a spectrographic buffer and an internal standard. The Hilger Littrow spectrograph was used and calibration effected by use of standard mixtures and the step-sector technique.

Chromium, Cobalt, Lead, Molybdeum, Nickel, Silver, Tin, Titanium, Vanadium, Zinc.—From an extract of the ash of the sample, these elements were co-precipitated in an aluminium matrix by organic reagents after the method of Mitchell and Scott (1947). Spectrochemical determination was then made by the variable internal standard method using the Hilger Littrow spectrograph as described by Davidson and Mitchell (1940).

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PESTS AND PETROLEUM

(Extracted from "Petroleum Press Service", December, 1954)

Farmers throughout the world have waged an age-long fight against insect attacks, plant diseases, and animal pests. Though this battle is now fought with very much more effective weapons than were available in earlier times for combating those grave menaces to the productivity of the land, the loss and destruction is still immense. The total value of agricultural produce lost through these causes alone possibly approaches £5,000 million a year for the world as a whole. American statisticians put the U.S.A.'s own losses from insects and plants pests as high as 8,000 million dollars (nearly £2,900 million); while crop losses through weeds add another 5,000 million dollars to that already frightening figure. It has been estimated that the total quantities of the world's grain crop destroyed by insects of all kinds would be sufficient to feed some 150 million people. The latter figure represents about 6 per cent of the world population, now standing at nearly 2,500 million people.

Modern science and technology have devised a great and steadily growing variety of highly potent tools of chemical warfare against insects and plant diseases, and farmers in many lands have been quick in taking advantage of their availability. There are, however, inevitable limits to their world-wide use on a scale large enough to ensure anything like the potential effectiveness of those weapons. In many countries—especially in the industrially least developed areas, whose populations most vitally depend on the fertility of the land—the cultivation of the soil is still done in more or less primitive fashion. There are neither the financial nor the technical resources available for enlisting the aid of the advanced mechanical and chemical facilities that are at the disposal of highly industrialized nations. Not even the possibilities, let alone the requirements for the proper application, of present-day pesticides are sufficiently known in agricultural communities. Indeed, it can hardly be otherwise. For some of the most efficient of these materials were only developed in very recent years, although the use of chemicals in the fight against insects and plant diseases has been a well-established practice in farming for over a century.

In that incessant battle, petroleum products have played a part right from the beginning. Their functions in this field are threefold. The oldest is the direct use of kerosene-soap emulsions as an insecticide—a simple, if only moderately effective, method of plant protection that has been retained to this day for certain purposes, especially in gardening. Similarly white oils, derived from special types of highly refined low-volatility petroleum fractions in the lubricating oil range, are sprayed in orchards for asphyxiating insects and destroying their eggs. Far more important and extensive is, however, the use of such white oils, as well as of kerosene and other light oils, as carriers for other toxic substances of different origin. For this purpose, the active chemical is dissolved in the oil and the solution made into an emulsion with water, with an oil-based or other surface-active agent serving as the emulsifier. The use of oil as a vehicle for distributing the toxic chemical enables the latter to be spread much more widely, and with more lasting effect, than would be the case if water alone were used as the poison carrier.

Another contribution of petroleum hydrocarbons to pest control lies in their function as supplementary chemical basestocks for the manufacture of the various synthetic pesticides that are now being produced on a steadily growing scale from a great variety of coal- and oil-derived organic chemicals. However, the quantities of chemical basestocks actually obtained from petro-chemical sources cannot be precisely ascertained, since these basestocks differ from those derived from coal or other sources only in origin, but not in chemical constitution. The amount of petro-chemicals so far absorbed in the production of synthetic pesticides are, however, likely to be still small, because the total world supplies of these comparatively new pesticides do not yet exceed a few hundred thousand tons a year.

This picture may change before very long, though the extent of this change must depend on the pace at which the demand for synthetic pesticides continues to grow. To-day the market for these is only in its early stages of development, as it did not come into existence till ten years or so ago. Before then, farmers

had to confine themselves to fighting their battle against insects and diseases mostly with oil sprays, nicotine and other vegetable extracts, and with inorganic compounds of arsenic, sulphur and copper, such as lead arsenate, lime sulphur, or copper sulphate, etc. They all have proved effective to a point and they are still widely employed in various ways. But their success generally rests on the use of high dosages and their action often lacks the precision and reliability required for meeting the greatly diversified demands of modern pest control.

Growing crops of various kinds are liable to be attacked not only by hundreds of different kinds of insects, but also by fungi, bacteria, or virus diseases. The diseases are probably the most perilous and most difficult to combat, but the ravages caused by insects may also reach formidable proportions, especially in the case of locusts and grasshoppers. Locusts alone are believed to be responsible for crop losses in tropical and sub-tropical countries of the order of £30 million a year. A further and even greater danger from insects arises from their action as carriers of diseases. The farmer's defence measures against these different menaces are no less varied. They comprise fumigation, the spraying and dusting of crops from the ground and from the air, the disinfection of seeds, of the soil, and of the harvest in store, as well as the use of the more recently evolved systemic pesticides. These latter are usually applied to the foliage and, after being absorbed, as transmitted to all parts of the stems and leaves, so as to make them toxic to attacking insects.

Obviously, no single pesticide can serve so many purposes. It is none the less desirable on economic grounds that the variety of products should be kept to a minimum by making each of them capable of widest possible application. On the other hand, pesticides must be selective to the extent that they are active only against the various pests, but harmless to the hosts and to the many useful micro-organisms whose action contributes to protecting plant life. Also, they must be potent enough to be effective, and to retain their effectiveness for a reasonably long time, even when used in comparatively small doses.

The art of synthesizing organic chemicals has achieved much during the past two decades in paving the way to these goals. In 1939 it produced DDT, a Swiss discovery of what is chemically defined as dichlorodiphenyltrichlorethane. The commercial introduction of this organic-chemical insecticide, synthesized on strictly scientific foundations, has not only revolutionized the techniques of agricultural pest control, but has also opened up important outlets for this product in domestic and other applications. DDT is now widely used, and with outstanding success, against grain weevils, tomato moth, tsetse flies, houseflies, mosquitoes and other insects. As a weapon against epidemics, it has proved singularly effective in checking malaria. It is equally valued for its great insect-killing power and for its long staying power, or residual effect. But DDT is by no means omnipotent. It has, for instance, no effect on the boll-weevil, the scourge of the cotton fields, nor on certain aphids. Also, some insects can breed new strains that are resistant to various insecticides, including DDT. Even its strong residual effect can in certain instances be a disadvantage, e.g., in the use of DDT for protecting dairy cows against flies or other insects, as traces of the chemical may eventually appear in the milk.

As the scientists' search went on for other synthetic compounds of yet greater all-round efficiency, benzene hexachloride, commonly known as BHC, was developed eight years ago almost simultaneously in the United Kingdom and in France, but first produced commercially in the U.S.A. BHC is effective against the cotton boll-weevil and various other insects that are immune to DDT, and current world sales of this product, at around 75,000 tons a year, are already of about the same order as those of DDT. But BHC, too, has its limitations, of which the most serious is application to food crops. That drawback is lessened in a modified benzene hexachloride preparation, known as Lindane, but the higher cost of this chemical greatly restricts its use, and the quantities at present produced are only a fraction of those of normal BHC. Meanwhile, the years 1946–50 saw a succession of other newly evolved synthetic pesticides. The chemical industry in the U.S. came out with chlordane and toxaphene, which are both—like DDT and BHC—chlorinated hydrocarbons, i.e. hydrocarbon compounds in which chlorine takes the place of one or more hydrogen atoms. Various organo-phosphorus products such as TEPP (for tetraethylpyrophosphate), parathion, malathion, etc., have also come on the market, as

well as other chlorinated hydrocarbons like methoxychlor, DDD, or heptachlor. All these products are in commercial use.

In 1948 the insecticides aldrin and dieldrin were introduced in the U.S., and from next year they will also be manufactured in the Netherlands. Their striking effectiveness first attracted world-wide attention in 1951–52, when large swarms of locusts invading wide areas of the Middle East were almost completely destroyed in a matter of days by aldrin, sprayed from the air and used as toxic component in ground bait. In 1953, dieldrin saved 75 million dollars'-worth of Californian rice crops from devastation by rice leafminers; in Switzerland it proved equally effective in protecting large acreages of potatoes from the Colorado beetle. Dieldrin is highly and persistently active against various disease carriers, such as mosquitoes, houseflies, ticks, and fleas, and both aldrin and dieldrin have also been used successfully against wire-worms, mole crickets, certain types of ants and ground-nesting termites. For special protection of crops against soil eelworms, a fumigant, known as D-D (for dichloropropane-dichloropropene), became available some time ago; it is obtained as by-product in the manufacture of allyl chloride from petroleum. By injecting it into the soil, the ellworms can be killed and the infested land restored to renewed productivity.

Many more types of synthetic multi-purpose pesticides than those cited above are already on the market, and more are being prepared in the agricultural research laboratories. New experiences generate new ideas. But much more experience has still to be gained. Even now, the scientific principles governing effective crop conservation are far from fully understood, and with widening knowledge, some of the newly forged chemical weapons against pests and diseases may well become obsolete before having reached the stage of fully-fledged commercial production. Apart from the intricate technical problems surrounding the development of new materials from the test-tube to the industrial stage, the economics of chemical pest control are extremely complex.

As G. Ordish has shown in his elucidating study of this subject,* pest and disease control is subject to the law of variable returns, like any other economic activity. The cost-to-benefit ratios differ widely between the various kinds of crops, the various kinds of chemicals, and the various techniques by which the latter are applied. In the case of high-value crops, the farmer's expenditure on pest control may amount to 20–25 per cent of his total costs, and the spectre of unsaleable surpluses from bumper crops may discourage such expense. The extent and intensity of pest infestation, which is greatly dependent on the never predictable vagaries of the weather, also has a big influence on pesticides usage. The sharp fluctuations in pesticides consumption over the past three years have signified the importance of such factors, but the general upward trend in demand is none the less evident. The increase in the use of the new synthetic materials has been most spectacular, though partly at the expense of some of the old-line chemicals. For instance, the U.S. production of DDT has risen since the end of the war from some 17,000 tons to over 50,000 tons a year, whereas that of lead arsenate has decreased from about 35,000 to less than 8,000 tons.

In the world as a whole, the older types of pesticides still predominate. From the scanty statistical information available, it appears that the aggregate world consumption of pesticides of all kinds is at present around three-quarters to a million tons a year, with the newer synthetic organic chemicals accounting roughly for a third of the total. Most of these latter products contain base chemicals now available—though not necessarily obtained—from petro-chemical sources. This applies not only to the various chlorinated hydrocarbons, but also to phosphorus and other compounds, embodying aromatic or olefinic and paraffinic components, such as benzene, ethylene, propylene, ethane, propane, methane, etc. All these basestocks may nowadays be derived from oil refining and natural gas operations, and so may some of the sulphur for the inorganic sulphur compounds.

American estimates have put the quantities of petroleum fractions currently absorbed in the production and application of pesticides in the U.S. at over 200,000 tons, but this total includes products used as solvents and as carriers. The amount of petro-chemicals directly employed as basestocks in the manufacture of pesticides can only be a fraction of that figure. The highest production of DDT

* *Untaken Harvest* by George Ordish, Constable & Co., Ltd., London, 1952

and BHC, the main tonnage products, which has so far been recorded in the U.S.A. totalled some 90,000 tons per annum and required about 50,000 tons of benzene, plus some 7,000 tons of ethylene. The benzene requirement represents about 5–6 per cent of the country's total consumption of benzene, of which, as yet, only about a third is obtained from petrochemicals. On this basis, the petroleum-derived benzene still plays only a small part in pesticides production, and for the world as a whole, the percentage would be quite insignificant. Even considering the very much larger quantities of petroleum used as carriers for insecticides, the oil industry's contribution to the promotion of farm production is so far very much smaller in the field of pest control than it is, for example, in the supply of nitrogenous fertilizers.

However, as pointed out before, modern methods of chemical warfare against insects and diseases are only beginning to be applied in agriculture on a wider front. There can be little doubt that the vast potentialities of recent scientific and technological achievements in pest control, in which several oil companies are taking an active part, will be increasingly exploited in the decades to come. Indeed, they must be, if food supplies are to keep pace with the rapid growth of the world's population. In many countries, the limits for extending the areas for food cultivation are already being approached. So increased food production commensurate with the fast rising needs can only be ensured by attaining higher crop yields per acre through greater use of chemicals that not only promote the growth of crops, but also protect them from destruction. The larger agriculture's demands for such chemicals grow, the more necessary it will be for the chemical industry to extend its basestock resources—already heavily taxed by the claims of hosts of industries—to the more and more amply available petroleum chemicals.

REVIEW

YEAR BOOK OF AGRICULTURAL CO-OPERATION, 1955, edited by the Horace Plunkett Foundation, London, and published by Basil Blackwell, Oxford. Price 25*s*.

The 1955 edition of this year book covers an even wider geographical area than previous editions, and there is a noticeable expansion of the information from the countries of Eastern Europe. The opening chapter on the relationship of the Food and Agriculture Organization to agricultural co-operatives explains how much importance is paid to agricultural organization in those countries where the rule has been every farmer for himself. It is, of course, axiomatic that efforts to increase the food production of the world as a whole are certain to fail unless the organization of marketing and co-operation amongst farmers is sufficiently efficient to provide an incentive to the primary producer, and F.A.O. has integrated its work on agricultural co-operation with that on agricultural production.

Although the title suggests that it would be of interest only to those who are directly or indirectly concerned with co-operative societies, there are many points in the book which would interest the farmer himself. For example, the chapter on South Africa includes a discussion on the setting up of "fodder banks"—reserves of dried fodder which can be drawn on by stockowners whose animals are in danger of dying during a drought. Considerable difficulty was experienced in working out the financial and agricultural aspects of this scheme, but a workable plan has now been found and the administration of the plan will doubtless be improved as more experience is gained. It should be emphasized that this fodder bank scheme was worked out and put into effect by the farmers themselves, through the South African Agricultural Union.

This is merely one example of the type of experience which is recorded in the book, and the editors are to be congratulated for avoiding academic financial discussions and for keeping in view the interests of the farmer. The book is much more readable than the title would lead one to expect.

D.W.D.

AGRICULTURAL RESEARCH IN THE SUDAN GEZIRA

By R. C. Maxwell Darling, Chief of the Research Division, Sudan Gezira Board, Wad Medani

(*Received for publication on 23rd July, 1955*)

In recent years the high quality of the long-staple cotton grown in the Sudan Gezira has gained world-wide recognition. As the following survey shows, much of the credit for the success of the Gezira Scheme is due to extensive experiment and research devoted to controlling pests and improving the breeds of plants.

Agricultural research in the Sudan may be said to have started in 1903 with the foundation of the Wellcome Tropical Research Laboratories through the munificence of Mr. H. S. Wellcome. Chemists and entomologists were the first agricultural scientists to be appointed and the W.T.R. Laboratories were attached to the Education Department. A botanist was appointed in 1911 and plant breeders and a plant physiologist after the first world war, attached to the Agricultural Department. In 1935 all agricultural research workers were united to the Agricultural Research Service as a part of the Department of Agriculture and since 1944 this has been known as the Research Division under the chief of the division.

The Gezira Research Farm

The Gezira Research Farm at Wad Medani which was started in 1918 is by far the largest research station in the Sudan and is also the headquarters of the Research Division. The organization consists of the sections of agronomy and plant physiology, botany and plant pathology, cotton breeding, entomology and soil research, each under its own head who is responsible to the chief of the Research Division.

Agriculture in the Gezira was confined to rain-grown sorghum until the Sennar Dam made irrigation possible on a large scale. The advent of irrigation introduced a new type of agriculture and raised numerous problems. Cotton was a new crop in the area and the best way of growing it, to give high yields and good quality and without causing soil deterioration, had to be discovered. This involved the choice or development of the most suitable variety, the best time to sow the crop, the best spacing, the amount and frequency of watering, tillage methods, rotations and the use of fertilizers. Almost invariably pests and diseases appear when a new crop is grown on a large scale, and this happened in the Gezira.

Aerial spraying against pests and diseases carried out on the million-acre Sudan Gezira cotton plantations

Agronomy

Agronomical experiments on sowing date, spacing, watering, fertilizers and rotations were begun early in the history of the Gezira Research Farm and the modern method of experimental layout evolved by R. A. Fisher was introduced in 1926—the year of its general adoption at Rothamsted Experimental Station in England—so that the Gezira Research Farm was using the best methods at an early stage in its development.

These experiments soon indicated how the cotton should be treated and the results were put into practice. In particular they stressed the importance of nitrogen as a plant nutrient and established the great value of applying nitrogenous fertilizers and using cultural practices which increased available soil nitrogen.

The main basic agricultural practices are incorporated in long-term experiments to observe seasonal effects and any changes which

may occur over a long period in rotations, application of fertilizers and so forth. These are large-scale, elaborate experiments and are unique as far as Africa and the Middle East are concerned. The results of the long-term rotation experiments are confirming the importance of *Dolichos lablab*, a leguminous crop, and of frequent resting periods in which no crop is grown, in maintaining the fertility of the soil. Long-term manurial trials have confirmed the continued value of nitrogenous fertilizer and have provided invaluable information on rates, times and methods of application.

The yield of cotton in the Gezira is subject to large seasonal fluctuations which cannot be wholly accounted for by pests or diseases. There is a good network of rain gauges in the scheme and an examination of the rainfall data shows a correlation between rainfall and yield, although only a very small proportion of the water requirements of the plant is supplied by rain. Heavy rain in the previous year is detrimental to the yield of the current crop whereas heavy rain in the six weeks before sowing is beneficial. From a combination of these two factors a formula was produced which enabled the yield to be forecast with considerable accuracy. The bad effect of the previous year's rain can be explained by increased weed growth on the fallows which would bear cotton in the following year, since experiments have shown that weeding these fallows increases the yield of the cotton. Investigations have so far failed to reveal the cause of the benefit from pre-sowing rain but it does not appear to be due to the direct effect of the rain on the soil.

A boat fitted with weed-cutting apparatus for clearing weeds from the minor canals

Water economy is important in the Gezira since irrigation water is limited whereas land is plentiful. Water is comparatively abundant from July to December, but strictly limited from January to March, after which none is available. Experiments are showing that water can be economized in the restricted period without a serious reduction in yield and this would enable a larger area of cotton to be grown with the existing supply of water.

One of the Gezira tenant-farmers cutting the heads of the "dura" crop grown on the irrigated land

DISEASES

The cotton yields in the Gezira were good for the first two years of the scheme but then began to deteriorate rapidly. Various theories were put forward to account for this, but it was probably mainly due to blackarm and leaf curl diseases, which became important at that time and were devastating in their effect. Blackarm was overcome by disinfecting the sowing seed and by burning the cotton sticks and debris in the field at the end of the season. Leaf curl was overcome by the production of a variety of cotton resistant to the disease and by uprooting the cotton plants at the end of the season instead of cutting them, to prevent the growth of infected ratoons during the rains; and by the control of *Hibiscus esculentus*, the only other host of importance. The enforcement of such strict sanitary measures was only made possible by the sense of reality and good organization of the Sudan Plantations Syndicate, who then managed the scheme, and these measures must be unique in the history of cotton-growing if not of large-scale agriculture. Any relaxation of these measures will cause a recrudescence of the diseases until such time as we can grow only cotton which is highly resistant to both diseases.

Cotton-breeding

The variety of cotton grown in the Gezira was at first Domains Sakel imported from Egypt. Leaf curl disease had been noticed as early as 1923; by 1927 it was becoming serious, and during the next few years it spread over the Gezira. This led to the production of a resistant variety of Sakel known as X1730A, which has been grown for a long time in the southern half of the Gezira Scheme where leaf curl is most prevalent. In the northern half, where conditions do not favour the disease so much, Domains Sakel is still grown, as it is of a higher quality.

Although sanitary measures keep blackarm under control, the advantages of a resistant type of cotton are obvious. Several kinds of cotton are resistant to the disease and the cotton breeders have been working to transfer this resistance to the long staple cottons without affecting their yield and quality. X1730L-1, the blackarm-resistant strain of X1730A, is in commercial production over a large area of Government and private schemes, but the variety is grown on only a small part of the Gezira Scheme.

The cotton-breeding policy is to produce strains of Domains Sakel and X1730A which are resistant to blackarm and leaf curl diseases, and have enough hairiness to make the plant resistant to the jassid leaf-hopper, for the control of which large sums are spent annually on spraying. This process should be accomplished without altering the quality of the present commercial varieties or reducing their yielding potential.

Experimental Agricultural School for Gezira Tenants' Sons

Pests

Pests, like diseases, soon became of importance in the Gezira. The first insect of importance was thrips, followed by flea beetle, pink bollworm and jassids. Pink bollworm has been kept at a fairly low level by such sanitary measures as treating the sowing seed and export of untreated seed. It was discovered in the early forties that jassids could be controlled by spraying and large increases in yield obtained. In 1945, therefore, Messrs. Pest Control, Ltd., were asked to carry out large-scale trials and now most of the Gezira and White Nile Schemes are sprayed to destroy jassids. Thrips and flea beetle can also be dealt with by the new insecticides.

The use of D.D.T. to control jassids leads to an increase in whitefly and, in seasons which favour this pest, very heavy infestations result. The entomologists have been trying to find an insecticide to deal with the whitefly; parathion is effective but it appears to encourage bollworms in the Gezira and so the search for a suitable insecticide for whitefly continues.

Soil Research

In the early days of the Wellcome Tropical Research Laboratories it was realized by the chemists that much of the future of the Sudan might depend on the interaction of the Nile water with the heavy clay soil of the Gezira. Analyses of the water and soil were begun and the study of this basic problem has continued. All the studies indicate that continued irrigation of Gezira soil with Blue Nile water will not result in soil deterioration.

After the first stage of the establishment of the Gezira Scheme a considerable development of pump irrigation schemes took place on the White Nile side of the Gezira. Here soils are of a number of different types, and their classification with regard to their suitability for irrigation became desirable. Previous basic studies of the properties of clays with varying amounts of sodium led to the development of a method of evaluating these soils and this method has been applied successfully, through soil surveys, to all major irrigation development since the early 1940's both on the White Nile, the Blue Nile and in the north-west extension of the Gezira.

In addition to soil surveys and its watch over the quality of the Gezira soil, the Soil Research Section has studied the fertility of Gezira soil in relation to the changes in the soil associated with different crop rotations and those which arise from year to year and play their part in the great problem of the fluctuating yields of the Gezira.

Fears were expressed in the early days of the Gezira Scheme that continued irrigation would lead to a rise of the water table and accumulation of salts in the surface soil, as happened with so many other irrigation schemes. The water table in the Gezira is deep, and investigation showed that, in this heavy alkaline clay, irrigation water penetrated rapidly to only three feet (one metre), after which the downward movement is greatly slowed up until it practically ceases below six feet (two metres). There is therefore no danger of a rising water table in the Gezira.

Results

The history of cotton yields in the Gezira Scheme reflects sound management backed by sound research.

Year	*Yield (k.p.f.)**	
1926–1927	4.78	Before disease became serious. Virgin land.
1928–34	2.70	Diseases and pests ravaging the crop.
1935–47	4.14	Diseases under control and rotation changed.
1948–54	4.50	Use of nitrogenous fertilizer begun on a large scale from 11 per cent in 1948 to 60 per cent from 1951 onwards. Large-scale spraying against jassids begun, increasing from 17 per cent of the cotton in 1948 to most of the Gezira being sprayed in 1949/50 and onwards.

* Kantars per feddan. 1 feddan = 4,200 sq. metres. 1 kantar = 44.93 kilograms.

It is usual for new irrigation schemes to start off well and then deteriorate. This deterioration began in the Gezira but its causes were realized and measures to combat it discovered. These were put into practice with the result that the average level of yields has remained high.

Cost of Research

Agricultural research in the Gezira is done by the Research Division of the Sudan Ministry of Agriculture. Some of the work at the Gezira Research Farm is also for the benefit of parts of the country other than the Gezira Scheme and only very rough figures can be given for the cost of research done mainly for the scheme. The following are these figures:—

	Egyptian pounds
Scientists, technical assistants and administrative staff	65,000
Labourers and lower-grade technicians	44,000
Apparatus, chemicals, books ..	4,500
Transport (including leave transport)	11,500
Other expenses	9,000
Total	£E.134,000

The cost of labour is high because a large amount of the research takes the form of field experiments, both large-scale and small-scale. The numerous sub-plots require a large number of supervisors for sowing and harvesting, and plant diagrams, counting of insects on various treatments or diseased plants in pathological work need a large number of observers.

The cotton area of the Gezira Scheme is 244,000 acres (101,170 hectares) from which a crop worth about £12,000,000 gross may be expected.

The cost of research is therefore in the neighbourhood of 1 per cent of the value of the crop.

FARM MANAGEMENT RESEARCH AND ADVISORY WORK

By E. S. Clayton, Economic Research Division, the Treasury, Kenya

(*Received for publication on 4th August*, 1955)

The farming community of Kenya has been provided with an advisory or extension service by the Department of Agriculture for some years. At present, this service ranges from the provision of detailed advice on problems of crop and stock husbandry to the drawing up of complicated farm plans where the reorganization of a farm is considered necessary. By virtue of the absence of information, it goes without saying that most of this advisory work is based on technical rather than economic considerations. It is true that with so much development yet to be made this is less serious here than it would be in Europe. But development must come fairly soon because declining fertility will make rotational farming a necessity, or will prompt less fertile land to be brought into cultivation. This will mean farming more intensively, acquiring new knowledge and new skills in animal husbandry, grassland management and fodder conservation. At this stage a premium will be placed on sound advice, for an intensive farm system requires a great deal of capital, and this implies that if things go wrong substantial losses can be made. In these circumstances, a short-term view of the needs of agricultural advisory work in Kenya is clearly out of place.

But sound advice requires that the economic consequences of technical recommendations should be known, at any rate approximately. Perhaps a simple example will illustrate this point. The price of whole milk has fallen and Farmer A decides to cut down on his purchased protein feed. Hitherto, his dairy herd averaged 1,000 gallons a year. Maintenance and the first gallon was produced from home-grown feeds and purchased concentrates provided for additional output. His agricultural officer quickly points out that by cutting down on concentrates his herd average has dropped to 900 gallons, and he is technically quite correct in urging Farmer A to restore his original ration and so get back to the higher yields. Inspection of his accounts, however, show that balancing his lower food bill against his reduced milk cheque (less milk at a lower price) income is down £15 but expenses by £35 a cow. Here the economic answer is different from the technical one, and, since a farmer's main aim is to stay in business, the latter recommendation is incorrect. This divergence in viewpoint arises because, in one case, the implications of diminishing returns to protein feed were not considered.

The principle of diminishing returns, though well known, is not always correctly understood.[1] It arises whenever a variable production factor is applied to a fixed factor—say fertilizer to a field of maize. In applying increased quantities of fertilizer to the field, after a certain point, it produces a smaller and smaller addition to total yield (Fig. 1). Applying a price to fertilizer and resulting output the most economic fertilizer rate arises when the cost of an extra unit of fertilizer is equal to the value of extra output resulting from it. Suppose the field produces six bags an acre without fertilizer and 56 lb. an acre of superphosphate yields an extra bag an acre, an additional 56 lb. an extra half bag and a further 56 lb. an extra quarter bag an acre. At current prices the most economic fertilizer rate is one hundredweight an acre since the second application of 56 lb. costs Sh. 18, which yields an extra half bag of maize also worth Sh. 18. The first 56 lb. yields twice its value; it pays, therefore, to increase the rate and beyond one hundredweight an acre the value of the extra fertilizer is not recovered from the resulting extra maize. Given the shape of the response curve, it follows that changes in the price of fertilizer and maize will require a change in the most economic fertilizer rate.

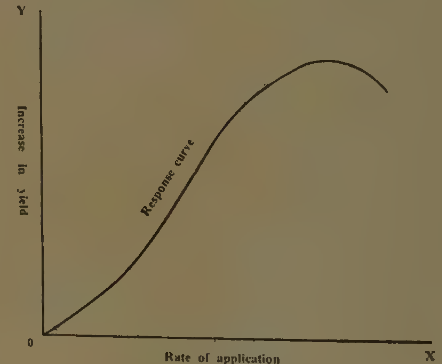

FIG. 1

This is not an academic issue as is made clear in most modern research on fertilizer responses, of which the Highland Fertilizer Scheme Report is a good example. This report actually gives optimum fertilizer rates for selected areas in the Highlands. The same principle is equally applicable to the feeding of livestock. After maintenance requirements have been met, feed is converted into liveweight gains, milk, or eggs with the same kind of relationship between input and output discussed above. In controlling the ration fed to bacon pigs, particularly in the later fattening stage, this fact is implicitly recognized by the farmer —that the heavier the pig the less liveweight gain from a given amount of feed. On the other hand, experiments carried out in America have shown the feed input/egg output relation to be almost a straight line, i.e. constant returns. In this exceptional case the uncontrolled feeding of laying hens is most profitable. It may be added that feeding standards like those laid down in "Rations for Livestock" are, strictly speaking, rule of thumb recommendations. A given ration is specified for maintenance then a *constant* production ration for each additional unit of output (say 4 lb. of cake for each gallon after maintenance plus one). This assumption is quite at variance with the known fact of diminishing returns but until experiments have established a whole range of response curves from livestock feeding constant returns is the only practical hypothesis.

Farm Income Analysis

It will be evident that the assumption made in this article is that the farmer has normal business instincts to make maximum profits. If, therefore, his profits appear lower than those of similar farms his first step will be to look for weakness in his own organization. This can be done by deriving from his farm accounts certain ratios called efficiency factors and comparing them with the average results from similar type farms. Some of these are physical and other financial ratios but all are designed to gauge the efficiency of his organization. Since farm profit depends on two factors—output and cost—these key factors are applied to both sides of the farm account. The following is a brief summary of some of the most useful efficiency factors.[2, 3]

Net Output is obtained by subtracting purchased feed and seeds from the gross output. This is used as a measure of production from the farm itself. Since, with prevailing price and cost relationships high output usually means high profits, a below-average net output will point the finger at one deficiency in farm organization.

System Index determines the relative intensity of the farming system. This is affected by the proportion of high value products to low value ones. In Europe this would be sugar beet as against oats or grass and beef or pigmeat as against milk, etc.

Yield Index.—This is a composite index which indicates the general level of crop and livestock yields and is compared with normal yields for the locality. A low yield index would lead to the inspection of individual yields.

Livestock Units per 100 *Feed Acres.*—This is a measure of livestock density particularly useful for checking on the effective use of land by ruminants.

Net Output per £100 *Labour.*—Since labour is a large item in farm costs it is vital for it to be used effectively. This factor shows how effectively labour is used on a farm.

Livestock Output per £100 *Feed.*—Feeding costs comprise about 80 per cent for pigs and 65 per cent for hens of total costs and this is quite a sensitive indicator of feeding efficiency.

Two points should be stressed regarding the above efficiency factors. To apply just one of them to a farm can be misleading; both output and expenditure should, therefore, be checked by a *group* of the appropriate factors. Secondly, these gauges should only be considered as warning flags, or indicators that something is wrong. The next step is a closer investigation of the point of doubt. For example, a low index of labour efficiency could arise through:—

(*a*) An unsuitable combination of enterprises resulting in a wide seasonal variation in pressure of work.

(*b*) Uneconomic size of productive enterprises.

(*c*) Inconvenient layout of farm or buildings.

(*d*) Inadequate or unsuitable machinery.

(*e*) Bad organization of tasks.

(*f*) Poor quality of labour or bad supervision of workers.

Each of these possibilities must be closely investigated on the spot. Once the weakness has been located, steps can be taken to put it right. But, because of the complicated nature

of farm organization this is not always a simple matter. Where the solution requires more than the application of another hundredweight of fertilizer or better labour supervision the problem of increasing efficiency is usually dealt with by means of farm budgeting.

Farm Budgeting.—It is helpful to touch on two or three simple principles underlying this method.[4, 5, 6] Business expenses fall into two categories—*fixed* and *variable* costs. Fixed costs are those which do not alter very much with farm output, and include rent, general maintenance and office expenses, the farm car and, once the farm policy is decided, wages of regular labour. Once these expenses have been undertaken they must be met every year unaltered by the fact that output may be at a high or low level. Variable costs are those which vary with output and are alterable at the farmer's wish. They include seed, fertilizers, fuel, feeding stuffs and casual labour.

The relevance of the above distinction will be shown by an example. A dairy farmer wishes to increase his herd by three cows because he has three empty stalls in the cowshed and his cowman can look after the extra cows. The financial gain from such a policy might be as follows:—

Revenue from extra milk		£250
Less:		
Feed for three cows	£130	
Replacement of one extra cow per year	£20	
		£150
Estimated Addition to Profits		£100

A profit of more than £33 a cow. It will be noticed that all the costs of keeping a dairy herd other than feed and herd replacement have been ignored in the sum above. They have, in fact, been considered as overhead or fixed costs associated with the dairy herd and scarcely affected by the three additional cows. However, this profitable alternative makes the farmer think in terms of increasing his herd by 10 cows. But this would mean extending his cowhouse to house all 10 cows and taking on some extra help. The calculation might be something like this—

Extra labour	£200
Depreciation on new building	£50
	£250

or £25 a cow. This reduces the extra profit to £8 a cow, i.e. £80 in all which is less than that accruing from three cows. This example shows the advantage of "spreading the overheads" over a greater output.

Another point worth making concerns what economists call "opportunity costs". If we are feeding homegrown barley to pigs, how do we value it? At what it costs to grow or at its market value? If the barley was not fed but sold it might bring £25 a ton. In feeding the barley, therefore, we forego the opportunity of making £25 a ton, and so it must be valued at this figure whatever it costs to produce. It follows that in marketing the barley through pigs it must show a profit (on a per baconer basis) exceeding £25 a ton, otherwise it would pay to sell the barley directly.

The simple sums above are examples of farm budgets. Basically, the method involves fixing on certain alternative farm plans, assembling the physical data relevant to these plans (called input/output data) and applying prices to these data. It can take the form of:—

Partial Budgeting where small adjustments to farm organization are considered.

Complete Budgeting where changes to the farm system are needed—new enterprises may be added and rotations altered. Normally, several alternative plans are decided on—a dairy herd, beef cattle instead of pigs, mechanized silage production instead of hay, etc.—in relation to current (or near future) prices, rotational needs, a farmer's preferences and capital position. These alternative plans are worked through to find out their relative profitability, which, of course, is the main factor affecting the choice of plan. Where the plan is complicated or costly a scheme must be worked out to introduce the plan gradually, and estimates made of yearly costs and returns over this period. It might be thought that, in view of the uncertainty of farming, the attempt to forecast net income is the task of a wizard and not an economist. It should be pointed out, however, that more emphasis is laid on the *comparative* size of net income than on its *absolute* size. The income forecast from a given reorganization is that expected on average over a period of years. Similarly, when comparing several farm plans the point is to see which gives the best return.

Group or Area Budgeting.—This is a most useful method of studying a homogeneous area. Normally, a random sample of farms is

taken from the area. Information relating to cropping, stocking, expenses and revenue is collected from these farms. In relation to this data a "modal" farm* is selected from the sample. This is a farm which carries out the "most usual" cropping, stocking and farm practices and in this sense, it is a typical farm of the area. An area would be studied like this presumably because it was, in some way, "depressed". It will be seen that by analysing the modal farm the management defects of the area can be discerned and, in the same way, remedies can be sought by applying the budget method described above to the farm under study. Thus, providing the selection of the modal farm is statistically sound, homogeneous areas can be dealt with on the basis of one farm.

Conclusions

This article has only briefly surveyed the field of farm management. The impression may have been given that it is all plain sailing, but nothing could be further from the truth. The major difficulty concerns the availability of the requisite information, and this is particularly so in Kenya. Most of the techniques outlined above have been thought of and pioneered in America, though in the last five years England has seen great activity in this field. The information for this work comes from two sources—the experiments of physical scientists, and the inquiries of the agricultural economist. The former give rise to input/output ratios; the yield responses of different rates of different fertilizers on different crops; the liveweight gains of livestock from different feeds over their life cycle; the rates at which different feeds substitute for each other at different levels of feeding. The latter include data about farm practices on crop and stock by labour, machinery and other resources; a wide range of financial information; efficiency factors and similar ratios; input/output data (though this is less refined than if derived from an experiment). Building up a body of information for effective farm management work does, of course, take time. This kind of work is flourishing now in England based on many years of research work. But, of course, it does not await a massive volume of information. Farm planning and the like can absorb information as it becomes available, all the while increasing the accuracy of results.

This kind of advisory work will have increasing value in Kenya both to farmers and to the community at large, since the economy is much influenced by the level of prosperity in agriculture. No one can claim that wheat- or maize-growing is sufficiently complicated to warrant much in the way of advisory services. However, the market and disease risks of monoculture, the serious loss of fertility resulting from this practice, and the lower world prices that are likely to prevail for cereals are resulting in a change in farm policy both at the official and the farm level. Livestock is recognized as the salvation and this brings into the picture grasses, legumes and, no doubt, roots. This will mean a Kenya agriculture providing a wider range of products than ever before and, at the farm level, a complicated (multi-product) mixed-farming system resembling the European model. This new farming system will involve great technical problems such as the breeding of economic grasses suitable in different areas and at different altitudes. Mention has been made of the capital required for a mixed system and the risks thereby involved. But more important will be the problem of management. With a number of crop and livestock enterprises on the farm, organization becomes much more complicated, and the contribution made by an enterprise to farm income more difficult to track. It is at this stage that physical and financial farm data is vital to allow the effect on income of changes in farm plans to be budgeted. Such methods will enable the farmers to face more easily the vicissitudes of nature and the market.

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* Sometimes it is necessary to select two or three farms.

LAND TENURE IN NORTHERN SUKUMALAND, TANGANYIKA

(An Analysis of Present-day Trends in Two Parishes)

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This work was undertaken in 1954 as an experiment. The method employed was to ask a number of the tax registrees in each parish a set number of questions relating to land tenure, the answers to which were recorded in tabular form and analysed by occupation, age, and clan for general details (Table I) and for the five principal crops (Tables II to VI) for each of the two parishes.

Mwamanyiri is a lake-shore parish in the Nassa chiefdom of Mwanza district, with a rainfall of about 30 in. per year and a population density of about 200 per square mile. The actual sample was composed of 74 tax registrees (of which two were women) out of a total list of 325. The occupied land of the parish is bunched round a bay of the lake into which a seasonal stream discharges, behind which strip the density thins out. Almost the whole of the parish land is cultivatable.

The second parish at Rumara is about a mile from the lake in the Hemera chiefdom of Mwanza district, with a rainfall of about 40 in. per year and a population density of about 400 per square mile. It is situated about two miles from Mwanza town in a countryside broken by many rocky outcrops and small hills. The sample was made up of 74 tax registrees (of which three were women) out of a total list of 187. The population is evenly distributed over the parish area.

Both Cory in "Sukuma Customary Law" (1953) and Malcolm in "Sukumaland" (1953) give details of Sukuma social practices which suggest a high degree of communalism in agriculture and house construction, whereas these samples suggest that such communal assistance is rare. The samples also suggest that the transfer and acquisition of land is now beginning to require the payment of money, and also that fields are rented for money, all of which are, in principle, opposed to Sukuma customary law. It was found that the Sukuma of Mwanza district shared these ideal conceptions and were prepared to state them in public in Rumara, where they themselves had given numerous examples of actual contrary practices.

The use of an intelligent and energetic African for these detailed inquiries enabled the author to gather information which would otherwise have ben unobtainable by a Government official.

General Details (Table I)

Any householder, male or female, and any male over 18 years, is legally bound to pay tax, by which time, according to our sample, almost everyone was married, although in Rumara five non-Sukuma form the majority of unmarried men.

In Mwamanyiri the majority of the men were cultivators, with a small number engaged in fishing and in other occupations such as trade or teaching. In Rumara slightly more than a quarter were cultivators, and only five were fishermen, whereas 36 were in other occupations such as labouring, lime-burning, painting, prostitution, cooking and beer brewing, trading, and in the Government employment. To a certain extent this parish has become a dormitory suburb for the town and it is this element which is brought out in their land tenure.

In house construction Mwamanyiri does not follow the ideal of communal assistance for the house-builder, where only seven men had any such help but only in one case in which

co-religionists helped, was the assistance given free; in the other cases the work was done for cash (five cases) or for food (one case). Only seven men had occupied vacant houses and over three-quarters of the sample had built their own houses unaided. Communal help from village associations for house-building was therefore no longer a prominent feature of rural life. In Rumara this trend had gone further, with only one man getting help from an association for which he paid cash. Fifteen men bought their houses for sums varying from £1 to £15, three men occupied vacant houses for nothing and two inherited them, while the remainder (49) had built their own houses. The trend is definitely towards individually built or bought houses.

In neither parish did land seem to be related to specific houses although the customary procedure used to be for a newcomer to occupy a vacant house and to cultivate the fields connected to it. The system now in practice seemed to be for the newcomer to build his own house and to be allocated vacant land by the headman from the uncultivated plots in the parish.

In both parishes the large majority of men were cultivating on their own and not in joint family groups; only 9 and 10 men respectively were working with their fathers. Although a son-in-law is considered by custom to be obliged to work for his father-in-law for a time after the marriage, it is significant that no one was recorded as having spent this season working for a father-in-law. About the same number (18 and 15) of householders had let land out on loan (this has been split up among the various crops to be discussed later) but trees had only taken on a separate value in Rumara. In neither parish did blood or clan relationship to the headman seem to have any preferential consequences.

As Mwamanyiri was deep in the country it could be expected to have a more stable community than Rumara, which was subject to urban influences. In the former there was only one non-Sukuma and everyone had been living there for more than six years, but in Rumara there was a substantial body of aliens and over half of the sample had been living there for less than 15 years. There was a noticeable disproportion between 52 cultivators in the former and 22 in the latter where 36 individuals were working outside agriculture and fishing.

The soil types used by the Sukuma themselves and which are used in the appendices devoted to the five crops studied are as follows:—

(a) *Isanga*.—Sandy soils on the lake shore most suitable for rice and potatoes.

(b) *Luseni*.—Pale coloured sandy soil suitable for rice and potatoes but not for cereals.

(c) *Ibushi*.—Friable black soil which is the most favourable for cotton as well as being good for cereals but useless for cassava and sweet potatoes.

(d) *Mbuga*.—A black valley soil which cracks deeply in the dry season; best for cereals.

(e) *Itongo*.—Unspecified soils on higher ground where past houses and cattle kraals have heavily manured the land, suitable for everything except potatoes.

(f) *Nduha*.—Red sandy laterized soil which is best for cereals.

Cotton Cultivation (Table II)

Owing to the rapid rise in the price of raw cotton, there has been a steady increase in the cotton acreage where population density allows. In Mwamanyiri over 90 per cent were cultivating cotton, of whom the majority had held their cotton fields for less than 10 years and almost all cultivated on the best soil. In Rumara only two-thirds of the sample were cultivating cotton within the parish, and it is likely that there were a number in addition who were cultivating in Geita district some distance away where there is plently of land available; over half had held their fields for less than 10 years and only four men were cultivating on the optimum soil which is thought to be one of the consequences of high population density.

In both parishes a large majority cultivated their fields by themselves and only a total of

17 men had used communal organizations for a single day's work or hired labour for a period. The details were as follows:—

1. *Mwamanyiri*

Bugika dance society.—Eight men who were paid Sh. 10 for one day.

Bugaru dance society.—Thirty-five and forty men who were paid Sh. 20 and Sh. 30 respectively for one day.

Neighbourhood Christian group.—Twelve men for one day for five pots of beer.

Five groups of hired labourers for a period varying from two men for Sh. 40 to seven men for two goats.

2. *Rumara*

Bucheyeke dance society.—Three men for a period who were paid Sh. 20.

Bucheyeke dance society.—Fifty men for one day for Sh. 10.

Mixed party of neighbours.—Forty persons for one day for food.

Five groups of hired labourers.—Two or three men for a period for Sh. 30.

These fields in Mwamanyiri were obtained in the majority of cases from the headman without payment, and a few were inherited or given by fathers, but in Rumara, although half were still obtaining their land free from the headman, a further eight had paid the headman from Sh. 15 to Sh. 30 in order to get their land; the remainder got their fields from fathers or relatives or by inheritance.

Sweet Potato Cultivation (Table III)

Potatoes are cultivated almost entirely by women although men may assist in the making of the beds. There was only one exception in both parishes to the almost universal rule of cultivation by the family alone, in which 15 men were paid three goats for making the potato beds before planting. In Mwamanyiri about 80 per cent were cultivating potatoes but in Rumara the total had fallen to about 70 per cent, although it is the easiest of all the crops to cultivate.

In both parishes the plots had been worked for varying periods which showed no particular trends, and everyone was cultivating their potatoes on suitable soils. In Mwamanyiri the vast majority had obtained their plots free, with the remainder receiving them by inheritance or from their fathers; in Rumara five plots again were obtained from the headman by paying sums from Sh. 10 to Sh. 35, although over half were obtained free.

Cereal Cultivation (Table IV)

Except for a small number in Rumara where only about 60 per cent were cultivating cereals at all, everyone cultivated the ordinary and not the bulrush millet. In Mwamanyiri although the majority worked their fields without help, a relatively high proportion (18) obtained help in their work which included:—

Bugaru dance society.—Twenty men for one day who were paid Sh. 50.

Porcupine hunters society.—Twenty-five men for one day who were paid Sh. 40.

One cultivator hired a tractor from the chief for an agreed acreage.

Eleven cultivators hired ox-ploughs for sums up to five goats or Sh. 50.

Bugaru dance society.—Three men worked for two goats for a period.

Buyeye snake society.—Twenty-five men worked for one day for beer.

In Rumara there were only five cultivators who got assistance.

Two neighbourhood groups of fifty persons who worked for one day for food.

Three men for a period for their keep.

No one was cultivating on an unsuitable soil and the lengths of occupation showed no trends, although the Rumara cultivators tended to have been in occupation for a shorter period than in the other village. In Mwamanyiri the fields were obtained free in the majority of cases and otherwise they were inherited or given by their fathers; in Rumara five had paid from Sh. 15 to Sh. 50 for their fields; a new aspect appeared in three men obtaining their fields from relatives.

Rice Cultivation (Table V)

In Mwamanyiri where there is plenty of land for food crops, the incentives to effort are more likely to be high cash value than high yields and this had resulted in only 8 per cent cultivating rice, although ten years ago it is thought that there were far greater numbers with rice fields, as there are large acreages of grassland with suitable soils which flood every year. In Rumara, where there is

less land available for food crops, rice may have taken on a greater value because of its higher yield per acre, and nearly two-thirds of the sample were rice cultivators. Most of these cultivators worked alone but seven used hired labour for a time for sums varying from Sh. 15 to Sh. 30; nearly a quarter had obtained their rice fields by paying the headman Sh. 10 to Sh. 30, while the remainder obtained them in the usual ways.

Cassava Cultivation (Table VI)

These figures for cassava cultivation must be seen against the fact that every householder is obliged by law to keep an acre of cassava as a famine reserve. In Mwamanyiri about 80 per cent were cultivating which shows that the law was being followed, but in Rumara the proportion had decreased so that only 42 householders out of 63 had cassava plots.

In neither parish was anyone cultivating on unsuitable soil and again the lengths of occupation showed no obvious trends, although the Rumara sample seemed to have a shorter period in occupation. In Mwamanyiri there was only one exception to the preference for working the cassava plot alone, where a religious teacher gave food to 50 of his boys to hoe his acre. In Rumara the majority again worked alone but two gave Sh. 30 and three goats to parties of 30 and 50 from the *Bugaru* and *Bucheyeke* dance societies respectively for a day's work, and nine employed one to four labourers for varying periods for from Sh. 5 to Sh. 50.

The plots in Mwamanyiri were obtained free, by inheritance or from their fathers, but in Rumara six plots were obtained by paying the headman from Sh. 10 to Sh. 20, and another plot was bought outright for £10 and two plots were obtained from friends, all of which is contrary to custom.

Conclusions

It is assumed that Sukuma land customs were evolved when there was plenty of land for everyone and that to-day the pressure of a growing population is causing modifications to these customs. According to this theory Mwamanyiri shows these customs in a relatively unmodified form and Rumara trends away from them where there is a high population density. It is suggested that emigration may only come after these trends have become apparent, and that the peasants modify their land customs in preference to moving to a new area unless there is some additional incentive such as a rise in cotton price.

The samples showed no bias for or against land holders on the grounds of occupation, age or clan; the man from the chief's clan had no advantage over the alien immigrant, nor did the older age group tend to abrogate valuable land to itself nor did the cultivators have observable advantages over non-cultivators in their land ownership. In house construction communal help was the exception in both parishes and everyone tended to build their own houses, except in Rumara where house purchase was beginning to become common.

Although custom allows for the inheritance by the elder son of the father's land, the sample suggests that there has been considerable family movement which makes it rare for land to be inherited, and that the average family obtains its fields independently of any family holdings which does not allow for any land improvement or fruit tree planting for posterity. The shortage of land seems to be the cause of the paying of fees to the headman of Rumara before fields could be obtained; although only one case of buying land appeared in the sampling, it is known to be more frequent nearer to the town where there is even greater demand.

In cultivating, the majority, with their wives, work their land alone; a few make use of communal associations to help with their work and there was a growing trend in Rumara to hire labour. In general, the trends are away from communal life towards an individuality which primarily prefers to work or build alone with a growing minority obtaining houses, land and labour for money. Essentially, Rumara is moving gradually from a barter to a money economy accompanying the change with far-reaching modifications to their principles of customary law.

The acknowledgment of such transfers of land in overpopulated areas and their possible registration would seem to be a wise precaution if undertaken before an extension of the high population density makes a complete tangle of land values and ownership.

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TABLE I.—GENERAL DETAILS, 1954

	Married	Unmarried	Divorced but not remarried	Widower but not remarried	Living in own home	Living with father	Living with father-in-law	Living with relatives	Living at work	House: occupied free	" bought	" built by himself alone	" built with help	" father's	" relative's	" father-in-law's	" on loan free	" rented	Cultivated by himself	" with his father	" with father-in-law	" with relatives	Not cultivating	Blood relative of headman	Same clan as headman	Any land tied to house	0 to 5 years resident in parish	6 to 10 years resident in parish	11 to 15 years resident in parish	16 to 20 years resident in parish	21 to 25 years resident in parish	26 yrs. and more resident in parish	Any land on loan	Any trees bought	Total in each category
A. MWAMANYIRI																																			
1. Cultivators ..	52	1	2	2	51	6	—	—	—	5	—	48	4	—	—	—	—	—	51	6	—	—	—	3	16	4	—	8	11	18	8	12	16	1	57
2. Fishermen ..	10	1	1	—	7	5	—	—	—	1	—	11	—	—	—	—	—	—	9	3	—	—	—	—	1	1	—	—	2	1	6	3	2	—	12
3. Other occupations	5	—	—	—	5	—	—	—	—	1	—	1	3	—	—	—	—	—	5	—	—	—	—	1	—	1	—	2	—	1	1	1	—	1	5
4. Over 35 years ..	43	—	2	1	46	—	—	—	—	6	—	36	4	—	—	—	—	—	46	—	—	—	—	3	15	5	—	8	11	10	7	10	14	2	46
5. Under 35 years ..	24	2	1	1	17	11	—	—	—	1	—	24	3	—	—	—	—	—	19	9	—	—	—	1	2	1	—	2	2	10	8	6	4	—	28
6. Chiefly clan ..	23	—	1	—	24	—	—	—	—	2	—	19	3	—	—	—	—	—	24	—	—	—	—	3	17	2	—	2	6	6	1	7	5	1	24
7. Other clans ..	43	2	2	2	38	11	—	—	—	4	—	41	4	—	—	—	—	—	40	9	—	—	—	1	—	3	—	5	7	14	14	9	13	1	49
8. Non-Sukumas ..	1	—	—	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	1
B. RUMARA																																			
1. Cultivators ..	22	1	1	—	19	5	—	—	—	—	1	20	—	2	—	—	—	1	20	4	—	—	—	—	9	2	1	10	3	3	—	7	6	2	24
2. Fishermen ..	5	—	1	—	6	—	—	—	—	1	2	3	—	—	—	—	—	—	6	—	—	—	—	1	1	2	1	3	—	1	—	1	—	2	6
3. Other occupations	36	7	1	—	38	6	—	—	—	2	13	26	1	2	—	—	—	—	36	6	—	—	—	2	6	5	10	10	6	9	1	8	9	9	44
4. Over 35 years ..	45	1	2	—	47	1	—	—	—	3	12	31	1	—	—	—	—	1	47	1	—	—	—	3	12	6	8	17	6	4	—	13	9	12	48
5. Under 35 years ..	18	7	1	—	16	10	—	—	—	—	4	18	—	4	—	—	—	—	17	9	—	—	—	—	4	3	4	6	3	9	1	3	6	1	26
6. Chiefly clan ..	6	—	—	—	6	—	—	—	—	1	1	4	—	—	—	—	—	—	6	—	—	—	—	3	3	2	1	2	—	1	—	2	1	1	6
7. Other clans ..	37	3	1	—	32	9	—	—	—	—	9	30	1	—	—	—	—	1	32	9	—	—	—	—	9	3	8	10	4	9	—	10	6	7	41
8. Non-Sukumas ..	20	5	2	—	25	2	—	—	—	2	6	15	—	4	—	—	—	—	26	1	—	—	—	—	14	4	3	11	5	3	1	4	8	5	27

TABLE II.—COTTON CULTIVATION, SEASON 1953–54

	Ibushi soil in field	Luseni soil in field	Nduha soil in field	Itongo soil in field	Mbuga soil in field	0 to 5 years cultivating this plot	6 to 10 years cultivating this plot	11 to 15 years cultivating this plot	16 to 20 years cultivating this plot	21 to 25 years cultivating this plot	26 years and more cultivating this plot	Cultivated by himself	” with communal turnout	” with help of religious group	” with help of neighbours	” with hired labour	Plot obtained on loan	” ” by clearing bush	” ” inherited	” ” in-law's fields	” ” father's fields	” ” relative's fields	” ” given by relatives	” ” given by father	” ” given by father-in-law	” ” given by friends	” ” given by headman: free	” ” given by headman: payment	” ” hired out to others	” ” bought	Total in each category
A. Mwamanyiri																															
1. Cultivators	55	1	—	—	—	5	29	10	8	3	1	50	—	3	1	2	(3)	—	2	—	—	—	—	6	—	—	48	—	—	—	56
2. Fishermen	9	—	—	—	—	—	6	3	—	—	—	7	—	1	—	1	—	—	—	—	—	—	—	2	—	—	7	—	—	—	9
3. Other occupations ..	4	1	—	—	—	—	2	—	1	1	1	4	—	—	—	1	—	—	—	—	—	—	—	—	—	—	5	—	—	—	5
4. Over 35 years	45	1	—	—	—	3	20	9	8	4	2	42	—	2	—	2	(2)	—	1	—	—	—	—	1	—	—	44	—	—	—	46
5. Under 35 years	23	1	—	—	—	2	17	4	1	—	—	19	—	2	1	2	(1)	—	1	—	—	—	—	7	—	—	16	—	—	—	24
6. Chiefly clan	24	—	—	—	—	—	12	6	3	1	2	23	—	1	—	—	(2)	—	—	—	—	—	—	1	—	—	23	—	—	—	24
7. Other clans	43	2	—	—	—	5	24	7	6	3	—	37	—	3	1	4	(1)	—	2	—	—	—	—	7	—	—	36	—	—	—	45
8. Non-Sukumas	1	—	—	—	—	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
B. Rumara																															
1. Cultivators	—	4	2	12	—	3	9	3	—	—	3	14	—	2	—	2	(1)	—	1	—	1	—	—	3	—	—	10	3	—	—	18
2. Fishermen	—	1	—	3	—	2	—	1	—	1	—	4	—	—	—	—	—	—	—	—	—	—	1	1	—	—	2	—	—	—	4
3. Other occupations ..	4	8	3	10	1	9	9	1	4	—	2	22	—	1	—	3	(3)	—	2	—	1	—	2	4	—	—	12	5	—	—	26
4. Over 35 years	3	9	2	20	1	6	14	5	4	1	5	31	—	2	—	2	(2)	—	—	—	1	—	3	3	—	—	22	6	—	—	35
5. Under 35 years	1	4	3	5	—	8	4	1	—	—	—	9	—	1	—	3	(2)	—	3	—	1	—	—	5	—	—	2	2	—	—	13
6. Chiefly clan	—	—	1	3	—	1	1	1	1	—	—	4	—	—	—	—	(1)	—	—	—	—	—	—	1	—	—	3	—	—	—	4
7. Other clans	1	7	1	16	1	10	8	1	2	1	3	23	—	3	—	—	—	—	—	—	2	—	3	6	—	—	12	3	—	—	26
8. Non-Sukumas	3	6	3	6	—	3	9	3	1	—	2	13	—	—	—	5	(3)	—	3	—	—	—	—	1	—	—	9	5	—	—	18

In MWAMANYIRI two men were not cultivating cotton and two men were working their fathers' fields.
In RUMARA 21 men were not cultivating, four men were working on their fathers' fields and one was cultivating elsewhere.
Figures in brackets are fields or parts of fields given out on loan.

TABLE III.—POTATO CULTIVATION, SEASON 1953–54

	Isanga soil in field	Luseni soil in field	Ibushi soil in field	Nduha soil in field	Itonga soil in field	0 to 5 years cultivating this plot	6 to 10 years cultivating this plot	11 to 15 years cultivating this plot	16 to 20 years cultivating this plot	21 to 25 years cultivating this plot	26 years and more cultivating this plot	Cultivated by himself	" with communal turnout	" with help of religious group	" with help of neighbours	" with hired labour	Plot obtained on loan	" " by clearing bush	" " inherited	" " in-law's fields	" " father's fields	" " relative's fields	" " given by relatives	" " given by father	" " given by father-in-law	" " given by friends	" " given by headman: free	" " given by headman: payment	" " hired out to others	" " bought	Total in each category
A. MWAMANYIRI																															
1. Cultivators	45	5	1	—	—	3	19	9	13	6	1	51	—	—	—	—	(5)	—	2	—	—	—	—	1	—	—	48	—	—	—	51
2. Fishermen	6	1	1	—	—	—	5	2	—	1	—	8	—	—	—	—	(1)	—	—	—	—	—	—	1	—	—	7	—	—	—	8
3. Other occupations ..	4	1	—	—	—	—	2	—	—	2	1	5	—	—	—	—	—	—	—	—	—	—	—	1	—	—	4	—	—	—	5
4. Over 35 years	42	2	2	—	—	3	17	7	9	8	2	46	—	—	—	—	(5)	—	1	—	—	—	—	2	—	—	43	—	—	—	46
5. Under 35 years	14	4	—	—	—	—	9	4	4	1	—	18	—	—	—	—	(1)	—	1	—	—	—	—	1	—	—	16	—	—	—	18
6. Chiefly clan	22	2	—	—	—	—	11	3	5	3	2	24	—	—	—	—	(2)	—	—	—	—	—	—	2	—	—	22	—	—	—	24
7. Other clans	33	4	2	—	—	3	14	8	8	6	—	39	—	—	—	—	(4)	—	2	—	—	—	—	1	—	—	36	—	—	—	39
8. Non-Sukumas	1	—	—	—	—	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
B. RUMARA																															
1. Cultivators	—	14	—	—	3	1	9	3	1	—	3	16	—	1	—	—	(1)	—	1	—	—	—	—	2	1	—	11	1	1	—	17
2. Fishermen	1	3	—	—	1	2	2	—	—	1	—	5	—	—	—	—	—	—	—	—	—	—	—	1	—	—	3	1	—	—	5
3. Other occupations ..	2	20	1	1	3	8	10	3	4	—	2	27	—	—	—	—	(1)	—	3	—	1	—	3	1	—	—	16	3	—	—	27
4. Over 35 years	2	31	—	—	5	5	16	6	5	1	5	—	—	—	—	—	(1)	—	—	—	1	—	2	3	1	—	27	4	—	—	38
5. Under 35 years	1	6	1	1	2	6	5	—	—	—	—	—	—	—	—	—	(1)	—	4	—	—	—	1	1	—	—	3	1	1	—	11
6. Chiefly clan	—	—	—	—	2	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	2
7. Other clans	2	23	—	—	3	5	17	3	1	—	2	—	—	—	—	—	(1)	—	—	—	1	—	3	2	1	—	21	—	—	—	28
8. Non-Sukumas	1	14	1	1	2	5	4	3	3	1	3	—	—	—	—	—	(1)	—	4	—	—	—	—	1	—	—	8	5	1	—	19

In MWANANYIRI nine men were cultivating their fathers' fields and one man was not cultivating.
In RUMARA 14 men were not cultivating, 10 men were cultivating their fathers' fields and one man was cultivating in a cassava field.
Figures in brackets are fields or parts of fields out on loan.

TABLE IV.—CEREAL CULTIVATION, SEASON 1953–54

	Bullrush Millet	Ordinary Millet	Itongo Soil in field	Luseni soil in field	Nduha soil in field	Ibushi soil in field	Mbuga soil in field	0 to 5 years cultivating this plot	6 to 10 years cultivating this plot	11 to 15 years cultivating this plot	16 to 20 years cultivating this plot	21 to 25 years cultivating this plot	26 years and more cultivating this plot	Cultivated by himself	" with communal turnout	" with help of religious group	" with help of neighbours	" with hired labour	Plot obtained on loan	" " by clearing bush	" " inherited	" " in-law's fields	" " father's fields	" " relative's fields	" " given by relatives	" " given by father	" " given by father-in-law	" " given by friends	" " given by headman: free	" " given by headman: payment	" " hired out to others	" " bought	Total in each category
A. MWAMANYIRI																																	
1. Cultivators..	—	51	—	—	—	—	51	3	17	10	14	6	1	39	—	3	1	8	(5)	—	2	—	—	—	—	1	—	—	48	—	—	—	51
2. Fishermen ..	—	8	—	—	—	—	8	—	5	2	—	1	—	5	—	1	—	2	—	—	—	—	—	—	—	1	—	—	10	—	—	—	8
3. Other occupations ..	—	5	—	—	—	—	5	—	2	—	—	2	1	2	—	1	—	2	—	—	—	—	—	—	—	1	—	—	4	—	—	—	5
4. Over 35 years	—	46	—	—	—	—	46	3	15	8	10	8	2	30	—	3	1	12	(3)	—	1	—	—	—	—	2	—	—	43	—	—	—	46
5. Under 35 years	—	18	—	—	—	—	18	—	9	4	4	1	—	16	—	2	—	—	(2)	—	1	—	—	—	—	1	—	—	16	—	—	—	18
6. Chiefly clan	—	24	—	—	—	—	24	—	10	4	5	3	2	18	—	3	—	3	(1)	—	—	—	—	—	—	2	—	—	22	—	—	—	24
7. Other clans..	—	39	—	—	—	—	39	3	13	8	9	6	—	28	—	2	1	8	(4)	—	2	—	—	—	—	1	—	—	36	—	—	—	39
8. Non-Sukumas	—	1	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
B. RUMARA																																	
1. Cultivators..	—	15	13	—	—	2	—	2	7	3	—	—	3	13	—	1	1	—	—	—	1	—	1	—	—	2	—	—	9	2	—	—	15
2. Fishermen ..	1	4	2	2	1	—	—	1	2	1	—	1	—	3	—	2	—	—	—	—	—	—	—	—	—	—	—	—	4	1	—	—	5
3. Other occupations ..	5	17	12	3	2	5	—	9	6	2	3	—	2	21	1	—	—	—	(2)	—	1	—	1	—	3	1	—	—	14	2	—	—	22
4. Over 35 years	5	18	12	4	2	5	—	7	12	5	3	1	5	28	1	3	1	—	—	—	—	—	2	—	3	1	—	—	22	5	—	—	33
5. Under 35 years	1	8	5	1	1	2	—	5	3	1	—	—	—	9	—	—	—	—	(2)	—	2	—	—	—	—	2	—	—	5	—	—	—	9
6. Chiefly clan	1	5	5	—	—	1	—	1	3	1	1	—	—	5	1	—	—	—	—	—	—	—	—	—	—	—	—	—	5	1	—	—	6
7. Other clans..	3	21	15	2	3	4	—	9	6	3	2	1	3	20	—	3	1	—	—	—	—	—	2	—	3	2	—	—	13	4	—	—	24
8. Non-Sukumas	2	10	7	3	—	2	—	2	6	2	—	—	2	12	—	—	—	—	(2)	—	2	—	—	—	—	1	—	—	9	—	—	—	12

In MWAMANYIRI ten men were cultivating their fathers' fields.
In RUMARA 23 men were not cultivating, nine men were cultivating their fathers' fields.
Figures in brackets are fields or parts of fields out on loan.

TABLE V.—RICE CULTIVATION, SEASON 1953–54

	Luseni soil in field	Isanga soil in field	0 to 5 years cultivating this plot	6 to 10 years cultivating this plot	11 to 15 years cultivating this plot	16 to 20 years cultivating this plot	21 to 25 years cultivating this plot	26 years and more cultivating this plot	Cultivated by himself	" with communal turnout	" with help of religious group	" with help of neighbours	" with hired labour	Plot obtained on loan	" " by clearing bush	" " inherited	" " in-law's fields	" " father's fields	" " relative's fields	" " given by relatives	" " given by father	" " given by father-in-law	" " given by friends	" " given by headman: free	" " given by headman: payment	" " hired out to others	" " bought	Total in each category
A. MWAMANYIRI																												
1. Cultivators ..	1	4	—	1	—	4	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—	—	
2. Fishermen ..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3. Other occupations ..	—	1	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
4. Over 35 years	1	4	—	—	—	4	1	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—	—	5
5. Under 35 years	—	1	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
6. Chiefly clan ..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7. Other clans ..	1	5	—	1	—	4	1	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	—	—	—	6
8. Non-Sukumas	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. RUMARA																												
1. Cultivators ..	15	—	—	9	2	1	—	3	14	—	—	—	1	(3)	—	1	—	—	—	—	2	—	—	9	3	—	—	15
2. Fishermen ..	2	—	—	2	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	2
3. Other occupations ..	25	—	9	8	3	3	—	2	19	—	—	—	6	1 (4)	—	—	—	1	—	4	2	—	—	12	5	—	—	25
4. Over 35 years	33	—	5	14	5	4	—	5	29	—	—	—	4	1 (5)	—	—	—	1	—	2	1	—	—	19	9	—	—	33
5. Under 35 years	9	—	4	5	—	—	—	—	6	—	—	—	3	(2)	—	1	—	—	—	2	3	—	—	2	1	—	—	9
6. Chiefly clan ..	3	—	1	1	—	1	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2	—	—	3
7. Other clans ..	19	—	5	8	1	2	—	3	16	—	—	—	3	(3)	—	—	—	1	—	3	3	—	—	9	3	—	—	19
8. Non-Sukumas	20	—	3	10	4	1	—	2	16	—	—	—	4	1 (4)	—	1	—	—	—	1	1	—	—	11	5	—	—	20

In MWAMANYIRI 60 men were not cultivating and eight men were cultivating their fathers' fields.
In RUMARA 23 men were not cultivating, nine men were cultivating their fathers' fields.
Figures in brackets are fields or parts of fields out on loan.

TABLE VI.—CASSAVA CULTIVATION, SEASON 1953–54

	Luseni soil in field	Itongo soil in field	Ibushi soil in field	Nduha soil in field	0 to 5 years cultivating this plot	6 to 10 years cultivating this plot	11 to 15 years cultivating this plot	16 to 20 years cultivating this plot	21 to 25 years cultivating this plot	26 years and more cultivating this plot	Cultivated by himself	" with communal turnout	" with help of religious group	" with help of neighbours	" with hired labour	Plot obtained on loan	" " by clearing bush	" " inherited	" " in-law's fields	" " father's fields	" " relative's fields	" " given by relatives	" " given by father	" " given by father-in-law	" " given by friends	" " given by headman: free	" " given by headman: payment	" " hired out to others	" " bought	Total in each category
A. MWAMANYIRI																														
1. Cultivators	7	—	43	—	2	18	10	13	6	1	50	—	—	—	—	(1)	—	2	—	—	—	—	1	—	—	47	—	—	—	50
2. Fishermen	3	—	6	—	—	6	2	—	1	—	9	—	—	—	—	(1)	—	—	—	—	—	—	2	—	—	7	—	—	—	9
3. Other occupations	1	—	3	—	—	2	—	—	1	1	3	—	1	—	—	—	—	—	—	—	—	—	1	—	—	3	—	—	—	4
4. Over 35 years	6	—	39	—	2	—	8	9	7	2	44	—	1	—	—	(2)	—	1	—	—	—	—	2	—	—	42	—	—	—	45
5. Under 35 years	5	—	13	—	—	9	4	4	1	—	18	—	—	—	—	—	—	1	—	—	—	—	2	—	—	15	—	—	—	18
6. Chiefly clan	6	—	16	—	—	10	4	5	2	1	21	—	1	—	—	—	—	—	—	—	—	—	2	—	—	20	—	—	—	22
7. Other clans	5	—	35	—	2	15	8	8	6	1	40	—	—	—	—	(2)	—	2	—	—	—	—	2	—	—	36	—	—	—	40
8. Non-Sukumas	—	—	1	—	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
B. RUMARA																														
1. Cultivators	6	14	1	—	3	11	3	1	—	3	19	—	—	—	2	(1)	—	1	—	—	—	—	4	—	—	11	4	1	—	21
2. Fishermen	2	2	—	—	1	1	1	—	1	—	4	—	—	—	—	—	—	—	—	—	—	—	1	—	1	2	—	—	—	4
3. Other occupations	10	15	—	2	10	9	3	3	—	2	18	—	2	—	7	(1)	—	2	—	1	—	1	3	—	1	16	2	—	1	27
4. Over 35 years	15	22	1	—	7	15	6	4	1	5	32	—	—	—	6	(1)	—	1	—	1	—	1	4	—	—	26	4	1	—	38
5. Under 35 years	3	9	—	2	7	6	1	—	—	—	9	—	2	—	3	(1)	—	2	—	—	—	—	4	—	2	3	2	—	1	14
6. Chiefly clan	3	3	—	—	1	4	1	—	—	—	6	—	—	—	—	—	—	—	—	—	—	—	1	—	—	5	—	—	—	6
7. Other clans	10	17	1	2	12	9	3	2	1	3	24	—	—	—	6	(1)	—	2	—	1	—	1	6	—	2	12	4	1	1	30
8. Non-Sukumas	5	11	—	—	1	8	3	2	—	2	11	—	2	—	3	(1)	—	1	—	—	—	—	1	—	—	12	2	—	—	16

In MWAMANYIRI nine men were cultivating their fathers' fields and two men were not cultivating.
In RUMARA 12 men were not cultivating, six men were cultivating their fathers' fields and four men mixed cassava with other crops.
Figures in brackets are fields or parts of fields out on loan.

MUNINGA (PTEROCARPUS ANGOLENSIS D.C.) IN THE WESTERN PROVINCE OF TANGANYIKA

I—Description, Distribution, and Silvicultural Characters

By J. S. Groome, Forest Department, Tanganyika

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Muninga is a medium-sized tree, rarely more than 50 feet high, of which often more than half is taken up by the crown which, when grown in open conditions, is large and spreading in width equal to or greater than the total height. The bole is usually straight and upright, rarely over 25 feet in length and 30 inches in diameter at breast height. Young stems often tend to be slightly wavy, a feature which may disappear in later life. The root system consists of a strong tap root in the young stage, supplemented by large, spreading lateral roots in later years.

Leaves. Usually alternate, unequally pinnate, with 4–8 pairs of opposite or sub-opposite leaflets; these leaflets are ovate to ovate-oblong, acuminate, with a glabrous, dark-green shiny upper surface, and a slightly paler, duller, lower surface.

Flowers. Inflorescence racemose. Flowers yellow or orange-yellow, fading to white when over; about 3–4 cm. across, having a sweet orange scent. The flower is typically Papilionaceous; the vexilla is 3–4 cm. broad with purple markings towards the base; the alæ have no such markings but each consists of a narrow stalk with a lobe at its juncture. The carina is similarly stalked and lobed and is joined on the under side at the tip for approximately ½ cm. only, enclosing the stamens. All petals are crinkled as a rule. The ten stamens are all joined at the base and have another partial division separating them into two sets of five situated on either side of the ovary. Flowering occurs toward the end of the dry season when the tree is leafless or the leaf buds are just opening; locally, this has been noticed as occurring in August–October.

Fruits. One to five or six mature fruits are found on a raceme. They are indehiscent and consist of a very hard round central seed box 1–1½ inches across covered with stiff bristles up to half an inch long and surrounded by a wide membranous wing 1–4 inches in radius with small bristles near the centre. The style is situated near the fruit stalk being bent far round. Young fruits are a slightly paler green than the leaves of the tree but turn pale brown on drying and persist on the tree throughout the leafless period. Galled fruits rather like brown berries are commonly found on the trees.

Small Twigs. On old trees these are moderately slender, 3–6 inches long, sometimes slightly pendulous, covered with fine, grey hairs. On young trees, they are thicker and stiff, up to 18 inches long. The main shoot is generally long, and side shoots short, moderately smooth, silvery-grey-brown with short, grey hairs.

Branches. These are stiff and fairly straight, the large branches, often spreading or nearly vertical, may start as a simple fork low down on the bole. Smaller branches and branchlets are spreading or horizontal, giving the crown when grown freely the appearance of an inverted cone. The bark of large branches is similar to that of the bole, and of small branches rough, sometimes flaky and dark grey, similar to that of oak.

Bole. Fairly cylindrical, straight or slightly wavy in young stages, upright except in areas where elephants are common; they seem to like to lean against this tree possibly for rubbing. Taper is very slight from 2 feet upwards and the base is not greatly enlarged nor fluted although large root junctions may cause bulges above ground.

The bark of the bole is up to 1½ inches thick, divided by horizontal and vertical fissures into rectangular or square segments from 1 inch square to 4 inches by 2 inches approximately. The outer bark of these segments has a tendency to be flaky. The natural colour is grey-red-brown and the general appearance is similar to Scots pine, but the lower 8 feet may be considerably blackened by fire. Occasionally the bark is covered with red or grey soil brought up by ants. The slash is characterized by the blood-red sap which exudes freely from vessels when a cut is made. Other features taken from a specimen tree are:

outer bark grey-black on outside, red-brown on inside with layers of pale-brown tissue; inner bark yellow-white, streaked with pinkish vessels which bleed freely if cut. The outer bark has a corky texture and is very thick, the inner bark is thin and neither markedly fibrous nor granular. Damage caused by fire occurs very commonly in the lower 4 or 5 feet, generally on one side only, resulting in internal rot. Damage due to honey-hunters is not infrequent; holes are hacked out of the stem to get at the bees' nests in dead branch holes or holes due originally to fire.

Timber. The timber is only moderately hard and heavy. Specimens weighed (air dry) 35, 36, 39 and 39½ lb. per cubic foot. All pieces were from different origins and showed a wide range of colour. When still green, weight may be up to 60 lb. a cubic foot. The heartwood is very distinct from the sapwood and the latter is very inferior in quality. The sapwood is a creamy-white colour whereas the heartwood varies from pale golden or olive-brown through mixtures of reds and browns to a dull purple-red-brown. The colour is not uniform and tends to alternate in light and dark bands following growth rings. Grain and texture vary but are usually moderately coarse with sometimes markedly interlocking fibres. Some trees only show a distinct "wavy grain" with "waves" about 0.1–0.2 inches wide. Growth rings are easily recognized in most trees but can be indistinct to the naked eye in others. Rings in the sapwood are less easily determined than in the heartwood. The commencement of a growing season is usually marked by the formation of large vessels, visible to the naked eye. These become fewer and smaller towards the end of the season, thus giving the darker colour to the wood. At the end of the ring is a continuous band of parenchyma two or three cells wide and throughout the ring are bands varying in length and becoming longer and slightly more numerous towards the outer edge of the ring. These bands make it very difficult to determine the precise edge of the ring even with a hand lens. Planed surfaces are mainly dull with a small amount of shine on the thick-walled fibres near the end of the growth rings. Cut vessels often glisten, due to gum deposits.

Muninga timber is in great demand in the Western Province, being put to almost every conceivable use, and completely taking the place of mvule (*Chlorophora excelsa*). This indiscriminate usage has led to a prejudice which is very difficult to overcome. Its woodworking qualities are excellent, it saws, planes, mortises and nails well; it takes a very good polish (french or plain), the strength/weight ratio and durability against white ants and weather conditions (except sapwood) make it a good building and general construction wood and its colour and working qualities make it a very fine furniture timber, although in very thin boards it tends to be brittle.

General Distribution of the Species

Muninga occurs in varying quantities throughout the savanna woodlands from the north-west of Kahama District and the east of Nzega District, where this type of vegetation enters the Province, in a more or less solid block southwards to the Rukwa Valley and Rungwa River where it continues into the Southern Highlands Province. Its spread to the north-west and west is limited by the highlands of Buha and by Lake Tanganyika; it occurs only in small quantities in the western parts of Kigoma District. In the south-west it fades out as the land rises to the Ufipa Plateau. In the east it extends into the Central Province along the whole of the provincial boundaries. The total area involved in the Western Province is about 30,000 to 35,000 square miles.

In these woodlands muninga occurs as a predominant and codominant tree, freely scattered or more or less gregarious, varying in density from only a few noticeable trees a square mile (e.g. north-west of Mpanda) to, exceptionally, an almost pure stand of many trees to the acre with very little else (e.g. about 15 miles west of Sitalike). It is found in association with the main *Brachystegia Pseudoberlinia* species and with other dry-forest species such as are found on rich mineral soils at Mpanda or in the Itigi thicket, both of these ecological types may be marginal types to the main *Brachystegia Pseudoberlinia* block.

The writer is of the opinion that the presence of muninga in quantity may be largely due to man-made forest conditions and that it may revert to a very scarce distribution if these conditions are not maintained. The three factors which seem to influence its distribution are, shifting cultivation, fire, and its light-demanding nature. Shifting cultivation is practised on a wide scale in the Western Province, and, because of sleeping sickness, covers large areas rapidly and moderately superficially. The return to the original plots is sufficiently

rapid to strain the coppicing powers of the *Brachystegia* and *Pseudoberlinia* species and weaken the stock. Muninga, on the other hand, has been protected for some long time partly by man-made laws and native realization of its value. Its place in tribal custom and superstition has not been ascertained, but in general muninga is favoured against the other competitors particularly in regard to damage and destruction by honey-hunters and by bee-keepers stripping bark for hives. Secondly, fire seems to do less damage to this species during the annual conflagrations than to many other species, most likely because of the thick, fire-resistant bark. The effect of fire on the hard fruits is an undetermined fact, but nevertheless, it must play a part in aiding germination by partial destruction of the cover, thus easing the final disintegration and allowing germination of the seed if not too badly burnt. Fire also tends to favour muninga by virtue of the fact that the other dominant trees shed naked seeds which must become badly burnt. Thirdly, the light-demanding nature of muninga is favoured by this open type of woodland with its occasional large gaps caused by fire and its scattered *shambas* periodically abandoned to natural recovery, particularly by the fiercer fires which arise from the extra grass and weeds found on abandoned cultivation.

The above three facts may or may not explain the presence of greater amounts of muninga of medium and large size, especially in the areas which have been subjected to the greatest degree of settlement, chiefly the strip of land about 50 miles wide on either side of the old slave trade routes and the present railway line. There does seem to be a gradual decrease from north-east to south-west, although enumeration figures show that this applies more particularly to the larger sizes of trees only.

Vegetation Types

The Brachystegia-Pseudoberlinia Woodland (*Miombo*). The main bulk of these forests is composed of this type of vegetation which contains a very large proportion of *Pseudoberlinia* and *Brachystegia* species usually about 50 per cent to 75 per cent but also up to 95 per cent of all large trees. The *Pseudoberlinia* species, chiefly *P. globiflora* or *P. paniculata*, may form up to 70 per cent of the tree crop with smaller amounts of *P. tomentosa* and *P. densiflora* occurring locally on sloping ground bordering *mbugas* or river beds. The *Brachystegia* species, more in variety, *B. wangermeeana, B. boehmii, B. longifolia, B. bussei,* and *B. spiciformis* also may form up to 50 per cent of the crop, individual species rarely being more than 25 per cent and only when a smaller amount of *Pseudoberlinias* are present. On lower hill slopes *B. utilis* and *B. floribunda* may be common with *B. microphylla* on the hilltops. Muninga is usually the commonest other component of the crop forming up to 25 per cent in inverse proportion to the amounts of *Pseudoberlinia* and *Brachystegia* species, more particularly the former. Over large areas muninga rarely forms more than a total of 10 per cent of the crop and the average is usually nearer 5 per cent. These percentages are based on the number of trees reaching the upper canopies. This inverse proportion to the *Brachystegia* and *Pseudoberlinia* species gives the impression that muninga is not a true component of the so-called "climax" forest. A variety of other species may be found in this type of forest but useful timbers are scarce. *Afzelia quanzensis* is found in economic quantities within 50 miles of the Central Line Railway usually less than one-tenth of the amount of muninga present. Also *Burkea africana, Albizzia antunesiana, Erythrophleum africanum* and *Sterculia quinqueloba* are usually found in association with muninga and vary in amounts proportionate to it.

The Itigi Thicket

This peculiar vegetation, believed by some to be the type which will follow the miombo in time, starts about 65 miles east of Tabora, between Malongwe and Tura and continues eastwards to Itigi. It is a dry deciduous thicket, 15–20 feet high containing *Burttia prunoidea, Bussea massaiensis, Baphia* sp., *Grewia* sp., *Commiphora* sp., *Combretum* sp. and *Canthium* sp. Towards its western edge are islands of miombo woodland usually containing good stems of muninga, also scattered throughout it, single trees of muninga occur standing out above the general level of the thicket. Whether these are relics of a previous type or new invaders of the thicket is not known, the presence of numerous young or medium-aged trees indicate that possibly the latter condition is true. The number of trees present compares favourably with *Pseudoberlinia Brachystegia* forest and muninga appears to be reasonably well established in this type of vegetation.

Bamboo Thicket and Dry Deciduous Mixed Forest

This is a term suggested for the type of forest occurring in the immediate vicinity of Mpanda and extending north-westwards towards Lake Tanganyika on mineral-rich soils and their transition stages to the sandstone plateau which runs from Kasulu south-eastwards to Uruwira and Nyonga. The most outstanding member of this community is the bamboo *Oxytenanthera abyssinica* which occurs as dense thickets on the lower slopes of hills and as scattered clumps through a variety of vegetation but generally more or less confined to red clay-loam soils. Characteristic trees are *Albizzia versicolor, sclerocarya* sp., ? *birrea, Combretum ternuifolium* and *Terminalia* sp., ? *bussei* and *Pterocarpus chrysothrix*. This vegetation type is considered to be a marginal strip to the main miombo mass and in consequence it is mixed with patches of miombo or contains scattered miombo tree species. Usually *Pseudoberlinia globiflora* and *P. paniculata* are conspicuous by their absence, though *P. densiflora* or *P. tomentosa* may be present. *Brachystegia* spp. may occur in small amounts as poorly grown trees. *Brachystegia boehmii* is the most common component. Muninga is common and grows well, though often short-boled as this type is generally less tall than the miombo forest. In the bamboo thickets themselves, only muninga, *Albizzia versicolor, Combretum* and *Acacia* species are at all common. Both *Brachystegia* and *Pseudoberlinia* species are normally absent.

Other Factors Connected with Distribution

The general topography of these woodlands is gently undulating with occasional isolated small hills or ridges and a few patches of hilly country. These undulating tracts are traversed by shallow depressions or valleys, usually badly drained seasonal swamps called *mbuga*, with more sharply defined river valleys in the vicinity of hills. Muninga appears to like good drainage and deep soil and is found in greatest quantities on the sloping ground of scree slopes, lower hillsides, the marginal slopes of well-defined rivers, and the sloping ground near *mbugas*. It is found in varying and generally smaller amounts on the flattish plateaux between the drainage channels when the soil is moderately deep, fairly well drained or sandy, but is almost completely absent from the *mbugas* themselves or pockets of impeded drainage.

Muninga seems to have considerable tolerance as regards type of soil and grows well on the light-grey sands or the red soils common in the miombo, though better growth has been noticed on the richer red soil with a higher clay content than on the sandier grey soil. The underlying or derivative rocks may be granite, gneisses or sandstone with belts of ironstone, and do not seem to affect growth to any great extent.

The grasses of the miombo are good indicators of the likely presence or absence of muninga. Tall *Hyparrhenia* sp. grows on the richer and better soils where it is common, while the finer grasses indicate areas rich in *Brachystegia* and *Pseudoberlinia* species, and the more open hard-pan areas of deteriorated woodland.

The rainfall of the area bearing muninga varies on the average from 25–30 inches in the east around Itigi to 40–45 inches in the west at Mpanda. Most of the rain falls between October and May with a spell of dry weather occurring in January and February. From May to October is one continuous dry season during which the ground vegetation dries out and is usually destroyed by the fierce travelling fires started by honey-hunters, travellers and other local inhabitants.

Silvicultural Characteristics of the Species

Natural Reproduction

Muninga is a profuse seed-bearer from about middle life (say 40–50 years) each year yielding a fair or good crop of fruits most of which persist on the tree for about six months before falling but may be still there to the next season. The fruits weigh 90–100 to the pound when dry, and husked seeds about 2,000 to the pound. Fruit dispersal is by wind and no animal agency seems to be involved though the possibility of the fruits being eaten by elephants and the hard shell partly softened by passing through the digestive organs has been suggested but scarcely proved. There is considerable doubt as to the part played by fire in aiding germination. There are indications that a light burn may be advantageous and a heavy fire inimical to regeneration. It should be noted that Troup in his "Silviculture of Indian Trees", describing the Indian *Pterocarpus* species, states, "Measures possible for the stimulating of natural reproduction are the exclusion of fire and grazing". The hardness of the seed pod is the chief obstacle to

efficient germination and lightly burnt pods examined at the end of the dry season have not seemed badly damaged nor to have lost their viability. However, considering the exceptionally fierce fires in long *Hyparrhenia* grass it is possible that not only actual burning, but also the intense heat could cause damage to viability. Experiments with the burning of grass on seed beds has been tried in Morogoro, but there are no records of results. A final suggestion from another source has been that termites in their ravages of the forest floor, either eat off the wings and outer shell or considerably reduce the seed case, allowing normal germination to occur.

The fruits begin to ripen on the tree at the end of the rainy season which is April to June in the Tabora area. 75 per cent to 90 per cent of the fruits contain good seed when collected fresh from the tree but only 30 per cent to 40 per cent are viable when fallen fruit is collected after the wings have rotted. Germination is epigeal with normally only one seedling to a pod.

From the above evidence and suggestions, the theory is advanced that muninga has adapted itself to the circumstances of nature and the annual fires and that something after the following fashion occurs. The tree flowers after the leafless period during which the annual fires occur, less damage being sustained by a leafless tree, and also there being less liability of damage to the reproductory system after the fires have occurred. Stimulus for flowering is probably caused by the period of dull or showery weather called in places the "mango rains". During this period bees are very active and the sweet-smelling flowers cause great attraction. During the rainy season the leaves and young fruit develop. These fruits ripen after the end of the rains and when the dry-season winds begin they are ready to fall or be blown off. Having fallen they lie in drying vegetation and suffer the annual fires which rarely miss much of the countryside. After burning they are weathered by the remainder of the dry season and are partly covered by blown ash and sand. When the rainy season comes round again they germinate, or should they fail in the first year a certain number manage to survive until the second or third years before germination occurs.

Vegetative reproduction of muninga is also common. Trees cut during early life and often large stumps coppice well and send up strong shoots. Considerable sizes of such shoots can be seen in the Tabora forests and probably date back 50 years to pole-cutting for buildings or clearing for cultivation before the present-day restrictions were in force. Whether these coppice shoots can attain timber size without silvicultural treatment is doubtful. Some silvicultural treatment would seem to be necessary in the younger stages in order to produce well-formed stems by reducing coppice shoots to one or two per stool.

Muninga has a habit of regenerating freely on cleaned or hoed land, providing there has been original stock on the land. This suggests that it either sends up root suckers or it can grow from the end of wounded roots. A good example of this regrowth has been observed at Simbo forest reserve, 16 miles north of Tabora. The method of increasing regeneration by trenching around older trees suggested by this habit appears worthy of investigation.

Artificial Regeneration

The first experiments were started in 1929 by Mr. L. T. Wigg (then an Assistant Conservator of Forests) in artificial regeneration by sowing fruits and seeds and planting truncheons in Tabora forest nursery (old aerodrome) and in Simbo and Tangwe forest reserves. Unfortunately this work was not followed up with good records and it is more or less impossible to trace the original documents and correlate the work with present results on the ground. A second series of experiments was laid down in 1939 and a third in 1944, in the prison plantations at Tabora, and in Simbo and Kwa Kasiga forest reserves. Here again, practically no data is available and visible results are not encouraging. For example, the line sown fruits at Kwa Kasiga had after seven years produced plants averaging less than 1 ft. high. Further experiments were started in 1950 and results are a little more promising.

Seed. Various treatments have been tried, using fruits dry, soaked for two to five days, boiled, burnt with a blow lamp, with or without the edge of the hull cut off or using hulled seed, dry or soaked. Germination was reported as poor (up to 20 per cent) in most cases. Cut-edged fruits produced results almost as good as hulled seeds. Germination occurred in 20 days with these fruits, provided they were not buried and half of the fruit remained above ground, the cut edge being in the soil. Since germination is epigeal the arching hypocotyl has difficulty in extracting cotyledons from the hull. A point of economic

importance is that in cutting fruits four men complete one sack a day whereas in hulling, they produce only a few ounces of seed.

Cuttings, Stakes and Truncheons. The first series of experiments were carried out by Mr. H. Burrows, Forester, at Tabora, in 1929. His report states that no result was obtained. Cuttings 3 to 3½ ft. long were planted for two-thirds of their length or totally buried in the ground and placed at an angle of 45 degrees to the vertical or upright. The cuttings originated from young poles or large tree branches, the latter were chosen in order to save damage to natural regrowth. The soil in which they were planted was a light sandy loam. In 1935, one of the lay brothers at Kipalapala Mission planted a plot of large muninga stakes approximately 9 ft. long, about 1½ ft. being buried in the ground in cultivated soil. The brother stated that the planting was carried out in September to October just before the rainy season started. The plot was beaten up annually for many years and roadside avenues of similar stakes were also planted. The result, as assessed in 1949 and 1952, was a fast growing plantation of very healthy trees containing one log length and approximately 30 per cent stocking. The growth of these stakes compares favourably with trees in good miombo forest. Unfortunately the exact order of planting for each individual stake is not known. This is not the only place where such stakes have been tried. Throughout the Western Province healthy speciments can be seen, but in all cases for a single planting the initial success is about 5 per cent and a plantation could only be established by a long series of replacements of the unsuccessful stakes.

In 1950 at Simbo forest reserve and Kabungu forest reserve (Mpanda), an experiment was laid down to produce scientific data regarding this method of reproduction. The results, as assessed after two years, show that the average survival for large branches is about 4 per cent, although other stakes planted haphazardly in silvicultural treatment plots at Simbo have produced very much better survival and growth. All these stakes were planted in the period September to October annually. Another series rather similar to the 1929 experiment was carried out in the Southern Province with a number of stakes planted throughout the year at monthly intervals and a further monthly series was laid down for the wet season period, i.e. November–March at Simbo and Kabungu in cultivated lines, but neither of these experiments have produced results which can be applied on a practical basis to the establishment of a plantation.

A new series of small twig cuttings was laid down in Tabora and Mpanda nurseries, the cuttings being 9 in. to 1 ft. long and up to ¾ in. in diameter, devoid of leaves or buds. The cuttings were soaked in a solution of Hortomone A for 24 and 48 hours before being planted in nursery beds of which the soil was or was not treated with Gammexane powder. Some of the cuttings after producing shoots had the shoots removed in order to stimulate further root growth. From the cuttings which were examined it was obvious that the Hortomone A stimulated root production, but a large percentage suffered from termite damage if the soil was not treated with Gammexane. On the other hand, an excess of Gammexane appears to have killed off the roots which were formed. The results of this experiment seem comparable to the experiments using the larger branches, being approximately 4 per cent survival in the above instances. However, the work has only been in progress for eight months and this is hardly long enough for suitable comparison.

Rootsuckers or Root Cuttings. This possible method of reproduction arising from observations at Simbo and Ichemba is that of applying a stimulus to surface roots causing them to send up shoots. The only possible stimulus appears to be wounding by cultivating the top soil or trenching around the stem. The percularity of these shoots is that they grow fast, with a very definite terminal growing point as opposed to the miserable shoots put out by seedlings and natural stock in the forest. A small bed of root cuttings approximately 1 ft. in length and up to 1½ in. in diameter is being planted in the Tabora nursery. It is too early to give any results for this experiment.

Handling of Young Plants

Muninga grown from seed in nursery beds tends to germinate spasmodically for a period of three or four months after 10 or 12 days. The seedling fairly quickly reaches a height of 4 to 6 in., having a strong parsnip-like tap-root of about 12 in. Transplanting is an operation which involves considerable loss, up to 50 per cent; further transplanting either to another bed or to the plantation site causes even greater losses and the final results are unsatisfactory. To overcome this difficulty

very early transplanting at 2 in. high into some form of box or pot is suggested, at the same time pruning the taproot and the top shoot. An alternative is to sow the seeds direct into the pots or boxes about three months before transferring them to the plantation site. An experiment has been laid down in Tabora nursery for trying broadcast seed with the Swaziland nursery bed technique which involves repeated root pruning throughout the period the young plants are in the nursery. No transplanting is involved during this period.

As opposed to the seedlings and transplants, root and shoot cuttings having ½ to 1 in. shoots and 6 to 9 in. of root can stand quite a lot of even poor handling. An experiment has been laid down at Uruma (near Tabora) using one-year, two-year and three-year root and shoot cuttings. At the time of writing the first and two-year stock has been put out into the experimental plantation, and the results are most encouraging, many plants showing very good strong shoots not of the type that die back or proceed without apparent terminal bud. It has been suggested that the first year's plants were the best of the growing stock. The second year's plants, the best of those remaining, and the balance of stock for the third planting will be of rather poor quality. This is because of an insufficient number from which to choose. The first planting at Uruma was followed by a very good wet season. The second planting (November, 1952) had only two or three days of rain followed by a month of very dry weather and two months of only very light rain. The root and shoot cuttings, however, survived this period very successfully. It is worthy of note that Troup mentions that direct sowing of seed is the most successful method of establishing *Pterocarpus* species in India, but this method is not so successful in the Western Province of Tanganyika. The 1948/49 trial plot at Mpanda using normal nursery transplants was least successful of all species tried. In the nursery, seedlings either stagnated or died back, which in natural forest would presumably get burnt off or die back from the drought in the dry season. Watering appears to make no difference to this characteristic.

Tending and Cleaning

Apart from the difficulties of germination and of the initial cutting away of the young plants more problems follow in later life. Muninga is a strong light demander and needs unrestricted space for full development after 15 years, about which time it reaches the general canopy of the forest. During its early stages up to a height of 15 ft. it appears able to stand a reasonable amount of high overhead shade but no actual crown interference. In the miombo woodland there is generally a space between the ground vegetation at, say 6 ft. and the general canopy at, say 25 ft. which is very open. During the early stages periodical burning may favour muninga by preventing the development of competitive thicket species and the more thin-barked trees. The two most important stages during which tending and cleaning operations should take place are the period of initial growth up to 6 ft. and the period during which the tree attempts to get through from the base to the top of the general canopy of the forest. It has been noticed in several areas that the very young stages are entirely absent or large numbers of pole stage trees are dying off at the top through their inability to complete with the denser foliage of *Brachystegia* and *Pseudoberlinia*.

Tending and cleaning operations should have two main objectives. Firstly, to give muninga room for free growth and, secondly, to improve the quality of the stem and of the crown. During the first stages of growth up to 6 or 8 ft. the following operations seem desirable:—

(i) The prevention of thicket and of excess grass growth by means of early burning or slashing.

(ii) The removal of interfering young miombo species, and at this stage if regeneration is insufficient, some method of cultivation with sowing or planting should be carried out.

During the stage of growth from 8 ft. to the height of the general canopy the pruning of side branches, the reduction of coppice to one stem and the removal of badly shaped stems should be carried out. From this stage onwards attention should be paid mainly to the development of the crown. The removal of interfering weed trees and the lopping of branches of surrounding trees should be carried out to allow free access to the upper canopy. Any final crop in these forests would not consist of muninga only, but would include mkora (*Afzelia quanzensis*) and the main secondary hardwoods, so that tending operations should also be carried out to the benefit of the better stems of these trees in proportion to their value in the crop.

A large proportion of the existing trees is useless because of their bad shape or defects in the form of rot and holes. The causes of these defects are several, but in the main relate to fire damage, slashing and honey-hunting. The remedies are concerned with the prevention of the agency which, in most cases is human. Early burning and the control of honey-hunting should have considerable effect. Fire often kills off the leading shoot, thus causing a fork or a crook. Fierce fires scorch the cambial layer where the bark is younger and thinner. This damage results in waviness and curves of the stem. Occasionally elephants push over break or bend considerable numbers of trees. They seem to choose muninga particularly.

THE NATURAL HISTORY OF TSETSE FLIES

An event of importance to East African biology is the publication this year of Professor P. A. Buxton's long awaited treatise on "The Natural History of Tsetse Flies"*. Although the early "Guide to the Study of Tsetse Flies" by Newstead, Evans and Potts (1924) will always remain a classic of the subject it is safe to say that the new book must replace, as a work of reference, all other studies, including those of Swynnerton and Hegh.

The volume of published research on *Glossina* has now reached massive proportions, and to the field worker in Africa, handicapped by limited library facilities, this book will be invaluable. It should also serve as a great stimulus to the publication of further work. The author animadverts on workers who "appear to be content to see their results appear in the form of a limited number of stencilled copies", a remark which will be received with mixed feelings by those who, as Government servants, are continually pressed to produce memoranda, usually before they are satisfied that their work merits publication. Nevertheless, it is to be hoped that Professor Buxton's strictures may help to prevent the burial of valuable studies in departmental files.

The book falls into two main sections, the first 13 chapters being devoted to *Glossina* either as an individual insect or as a population; the last three chapters derive from its economic importance as a vector of trypanosomiasis. The author carries his survey to the end of 1952 and it is an indication of the amount of work now being done that the informed reader will often recall more recent work which will demand inclusion in a future edition. Professor Buxton notes that "*Glossina* is indeed one of the classical organisms on which certain methods of field survey and of estimating populations have been developed" and that this is so is a tribute to the comparatively few workers to whom these techniques are due. Laboratory research, in which Professor Buxton was himself a pioneer, has been less well developed because, so often, the demands of the tsetse problem as a practical issue have forced the research worker to attempt to combine his studies with schemes of tsetse control. It is, of course, largely due to Professor Buxton that this unsatisfactory situation has, in recent years, been corrected, and a research organization set up under the East Africa High Commission, in which it should be possible to fill the gaps in our knowledge which prevent the final solution of the economic problem created by the presence of *Glossina* in Africa.

In a book of this size it is perhaps inevitable that there should be some statements with which the reader will disagree. The record on page 42 of *G. fuscipleuris* just east of Lake Nyasa is surely wrong. Perhaps more serious, however, is the misinterpretation (due possibly to the last minute inclusion of recent work) of Burtt's studies on larviposition (pp. 364 and 370). Burtt showed that the fully pregnant female *G. swynnertoni* rests on the underside of low branches and then drops to the ground immediately before parturition, not that the larva itself is so dropped. Most workers who have considered the problem of tsetse distribution will appreciate the view expressed when the book was in draft that "it seems unlikely that further collecting will reveal new species", for at that time none had appeared since 1929. However, a footnote (p. 17) shows that in 1952 *G. vanhoofi* was described and it is, of course, now known that a description of the 22nd species is now in the press.

East Africa's debt to professor Buxton has for long been a large one. This beautifully produced and extremely readable volume greatly increases it.

J. FORD.

* "The Natural History of Tsetse Flies" by P. A. Buxton, C.M.G., F.R.S. Published by H. K. Lewis (1955) as Memoir 10 of the London School of Hygiene and Tropical Medicine. 816 pages, 47 plates. Price, four guineas

REVIEWS

TANGANYIKA. A review of its resources and their development, prepared under the direction of J. F. R. Hill, and edited by J. P. Moffett. Published by the Government of Tanganyika, 1955, and obtainable from the Government Printer, Dar es Salaam, and from the Crown Agents for the Oversea Governments and Administrations, 4 Millbank, London. Price 42*s*.

This volume of 924 pages surveys the past and present development of the Territory and the future requirements as they are seen to-day. The book is divided into ten parts: the country and its people; political structure; social services; communications; production—the fundamental factors; production—economic resources of the Territory; trade; finance; urban development; general development. Eleven maps are included.

The section on agriculture, which is included in the part dealing with the economic resources of the Territory, occupies over 200 pages, and this complex subject has been covered thoroughly yet clearly in all its aspects, except soil classification and survey, which is included in the part entitled "Production—the fundamental factors", since soil research is carried out by the Government Chemist's Department. Forestry occupies 29 pages and animal husbandry and veterinary science 78 pages, while smaller sections are devoted to applied chemistry, fisheries, tsetse control and research, land tenure, water development, and co-operative development. These sections, which are of particular interest in this review, give a detailed picture of the problems of food production, plantation agriculture, forest products and land utilization. The individual sections were prepared by the appropriate technical Departments, but the persistence of conciseness and clarity throughout the book must be due, wholly or partly, to the editor, who is to be congratulated on the form of presentation of the information. In a reference book of this size the index is of great importance, and in 53 pages the subjects are indexed in great detail, so that it is easy to find references to a subject or to a particular branch of a subject.

Perhaps the greatest value of this book is that it contains a mass of information which had been buried in departmental files, and it provides a means of making use of past experience in planning future developments.

D.W.D.

THE AGRICULTURAL REVIEW, Vol. 1, No. 1, edited by Sir James Scott Watson, and published monthly by Hulton Press Ltd., 43 Shoe Lane, London, E.C.4. Price 2*s*. 6*d*. per copy, annual subscription 30*s*. post free.

This new periodical replaces "The Agricultural Bulletin", which was published by the British Council, as the latter body does not compete when other Journals cover the same field of interest. In the leader to this issue Sir James Scott Watson states: "It will be the major purpose of the Review to convey, in language as plain as may be, such new information as may help the improver to improve. It will also be our endeavour to discuss those lines of research that bear promise for the not too distant future."

The first number fulfils this promise. An article by Professor R. L. Wain describes a new principle of weed control which opens up great possibilities for the future: Dr. P. S. Hudson's article on sugar beet shows how that plant has been improved out of all recognition. Mr. S. R. Wragg's article, "The Farm as a Business" will appeal to all who wish to know how the money comes and goes on the farm, and Dr. D. P. Cuthbertson's article on the effects of cobalt, copper, and molybdenum deficiencies in livestock is of particular interest for those parts of East Africa which are known to be deficient in one or more of the trace elements. The subsidiary articles cover the 27th French International Farm Machinery Show, poultry breeding, lime-induced chlorosis in fruit crops, silage-making, antibiotics, control of potato virus diseases, economic review, and there are abstracts of 17 technical papers on a wide range of agricultural subjects.

This journal will provide farmers in the tropics, as elsewhere, with interesting and stimulating information on the progress of modern agricultural practice in temperate climates, although the familiar warning must be repeated that new agricultural principles and practices which have been found effective in temperate climates must be tried, tested, and proved on a small scale in warmer climates and higher altitudes before it is safe to apply them on a farming scale.

D.W.D.

FILED IN STACKS

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